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Much has changed since 1665, when Richard Lower performed the first documented blood transfusion in a dog in the UK. This transfusion was a direct donor-to-recipient transfusion accomplished by directly linking the jugular veins of the donor and the recipient using a hollowed out reed; Lower performed this experiment in dogs before the first documented transfusion in humans in 1667 in France. Of course, because anticoagulants were not used in those days, repeated clotting of the reed and the lack of positive hydrostatic pressure in the vein of the donor resulted in a major failure. After several experiments, Lower succeeded in connecting the carotid artery of the donor to the jugular vein of the recipient, and delivered the first “effective transfusion”. In 1666, Lower performed the first transfusion experiment in an anemic dog; he selected “a medium sized dog and drew off its blood from an exposed jugular vein as I could without killing it”. He thus developed the first “model” of acute hypovolemic anemia. Then he selected a large dog as the donor, and sutured a reed from his carotid into the recipients jugular. Astonishing, after the procedure, the smaller dog virtually came back from the dead (D Starr: Blood-An Epic History of Medicine and Commerce. NY, Harper Collins, 1998).

We’ve come a long way since then…We now can blood type, cross-match, have our own small or large blood bank, or order products from a sizable “menu” from commercial blood banks; in effects, transfusion medicine has become part of the daily life of the practicing veterinarian. The most common reason for transfusion in both human and veterinary medicine is oxygen-carrying support for anemic patients.

ANEMIA

Once it has been established that the patient is anemic, it should be determined whether the anemia is regenerative or nonregenerative. This is accomplished either by obtaining a reticulocyte count during a routine CBC (some of the in-house analyzers, such as the LaserCyte from IDEXX Laboratories, Westbrook, ME, provide reticulocyte counts) or by evaluating a blood smear for the presence of polychromatia. This reflects the pathogenesis of the anemia, thereby dictating the most logical diagnostic and therapeutic approach. From a transfusion medicine standpoint, it is also important to establish if the anemia is normovolemic (isovolemic) or hypovolemic (see below).

Regenerative anemias always stem from extra-marrow causes, because the presence of reticulocytes or polychromatophilic RBCs (i.e., immature RBCs) in the circulation is a clear indication of a functional bone marrow. Regenerative anemias can result only from hemolysis or blood loss; a dog or cat with regenerative anemia and hypoproteinemia likely has blood loss. Nonregenerative anemias can be caused by bone marrow or extra-marrow disorders, such as erythroid hypoproliferation, chronic inflammatory disease, chronic renal disease, and acute hemorrhage or hemolysis (first 48 to 96 hours). Although traditionally iron deficiency anemias (IDAs) are classified as nonregenerative, most dogs with chronic blood loss leading to iron deficiency display a mild (to moderate) degree of regeneration, and the RBC indices are different than in other nonregenerative anemias (see below); therefore, I prefer to classify IDA in a separate category. Regenerative anemias are usually acute, whereas nonregenerative anemias are either peracute (i.e., blood loss or hemolysis of less than 48 hours’ duration) or, more often, chronic.

During the initial clinical evaluation of an anemic patient, examination of the blood smear usually helps determine whether the bone marrow is responding appropriately to the anemia (i.e., whether the anemia is regenerative or not). Several pieces of information can be acquired during the examination of a good-quality, properly stained blood smear, including the RBC size and
morphology, the presence of autoagglutination, the approximate numbers and the morphology of white blood cells and platelets, the presence of nucleated RBCs, the presence of polychromasia (indicative of regeneration), and the presence of RBC parasites. The clinician should do a cursory evaluation of the blood smear; a blood sample should be submitted to a diagnostic laboratory for further analysis and evaluation by a clinical pathologist if the diagnosis is still uncertain after evaluating the blood smear. It is important to conduct this evaluation in a monolayer field (in which the erythrocytes are in a single layer and 50% of the cells are touching) under oil immersion lens.

A CBC and a reticulocyte count in an anemic patient provide more absolute data by which to assess the degree of regeneration. However, the information presented below must be used cautiously, because the number of reticulocytes should increase proportionally to the decrease in the HCT. For example, a reticulocyte count of 120,000/ml or of 4% represents an appropriate response for a dog with a HCT of 30% but not for one with a HCT of 10%. The following points generally hold true:

1. If the RBC indices are *macrocytic* and *hypochromic*, the anemia most likely is associated with the presence of high numbers of reticulocytes (which are larger and contain less Hb than mature RBCs); therefore the anemia is likely regenerative.

2. If the reticulocyte count is more than 120,000/ml or 2% and the anemia is mild to moderate, the anemia is likely regenerative.

Commercial blood banks have a variety of components available for veterinarians. Most blood banks have pRBCs from dogs and cats, whole fresh blood (WFB) from dogs and cats, fresh frozen plasma (FFP) and stored plasma (SP) from dogs and cats, canine cryoprecipitate (CRYO), and canine cryopoor plasma. Platelet-rich plasma (PRP) and platelet concentrates (PLATES) are available in some commercial blood banks.

**BLOOD GROUPS**

Blood groups in cats include A, B, and AB. Cats tested in the United States have almost exclusively been A-type; the prevalence of B-type cats varies greatly from region to region and among breeds. Breeds in which 15% to 30% of the cats are B-type include Abyssinian, Birman, Himalayan, Persian, Scottish Fold, and Somali; breeds in which more than 30% of cats are B-type include the British Shorthair and the Devon Rex. Because fatal transfusion reactions commonly occur in B-type cats receiving A-type blood, cats should always be crossmatched or typed before receiving a transfusion. In those cases, a B-type cat should be used as a donor. All the B-type cats seen in our clinic in the past 5 years have been domestic short-haired cats. Blood typing is also vital in cattery situations to prevent neonatal isoerythrolysis in A- or AB-type kittens born to B-type queens.

**CROSSMATCHING AND BLOOD TYPING**

Crossmatching is an alternative to blood typing in in-house donors or in animals that have had prior transfusions, in cats, or in animals that will require multiple transfusions. Crossmatching detects many incompatibilities but does not guarantee complete compatibility. Rapid, cage-side blood typing cards for DEA 1.1 in dogs and for groups A and B in cats are commercially available (Rapid Vet-H, dms/laboratories, Flemington, N.J.). A kit for rapid cross-matching will soon be commercially available.

**TRANSFUSION OF THE ANEMIC PATIENT**

Most of the anemias encountered in small animal practice are *normovolemic*; these include hemolytic anemia, anemia of chronic disease, anemia of renal disease, iron deficiency anemias, and bone marrow disorders. Blood loss anemia is typically associated with *hypovolemia*. From a transfusion medicine standpoint, it is important to recognize these features, since patient with normo- or isovolemic anemias benefit from receiving a highly concentrated RBC suspension (i.e. pRBCs), whereas in patients with hypovolemic anemia, WFB is more likely to be beneficial; alternatively, in the latter a combination of pRBCs and FFP (or SP) can be used.
In dogs, the majority of RBC transfusions (ie; pRBCs or WFB) are used for patients with blood loss or hemolysis. In a recent study in cats, we documented that 75% of the units of WFB and 80% of the units of pRBCs were used for anemia; the 2 most common indications were blood loss (perioperatively) and anemia of chronic renal failure (Castellanos et al; J Vet Intern Med, 18:529-532, 2004).

In cats, one unit of WFB (approximately 60 ml) or one unit of pRBCs (25-45 ml) increase the recipient's hematocrit by 6 percentage points (i.e.; from 15% to 21%. The empirical initial doses of RBC components are approximately 10 ml/kg of pRBCs or 20 ml/kg of WB, and the typical rate of administration is 10-20 ml/kg; the rate of administration should be slower in dogs with congestive heart failure.

“Transfusion trigger” is a term utilized to define the hematocrit or hemoglobin concentration at which a human patient should receive RBC support. This number was generated based on experiments evaluating hepatic elimination of bacteria translocated from the GI tract (ie; higher likelihood of sepsis). The transfusion trigger in humans is a hemoglobin concentration of 8 gm/dL (or a hematocrit of 24%). As of now, the transfusion trigger has not been validated for dogs or cats. Consequently, most clinicians use the patient’s general health status, rather than the hematocrit, to decide when a patient should be transfused.

Two clinical questions that arise frequently are:

a. Should I transfuse a dog with autoagglutinating immune-mediated hemolytic anemia (IHA)?

b. Should I transfuse a dog with longstanding chronic anemia?

a. Transfusing patients with autoagglutinating IHA should be done on an “as needed” basis. Blood typing using the cards will frequently yield a false-positive 1.1+ due to the preexisting agglutination, so universal donor blood or pRBCs should always be used, if available. Cross-matching is ideal, but sometimes the urgency of the situation calls for a transfusion before the cross-matching is available. We typically administer universal donor pRBCs at a very slow rate, and observe the recipient for hemolysis or pyrexia; if after 15 minutes no untoward reactions develop, we increase the rate to the required one. Intravascular hemolysis or fever usually results in discontinuation of the transfusion.

b. A dog or cat with pure red cell aplasia (PRCA) typically presents with fairly mild clinical signs despite the severity of the anemia (i.e.; the typical hematocrit in PRCA patients is 10-15%). The question then is: should we transfuse this patient. Because these patients are usually asymptomatic, I prefer to withhold the transfusion of pRBCs. The main reason: stored RBCs have a higher affinity for oxygen due to changes in their 2,3-DPG content; consequently, there is little, if any, immediate benefit to the recipient, since the RBCs need to be “recharged” in then patient.

**BLOOD ADMINISTRATION**

Refrigerated blood may be warmed before or during administration, particularly in small dogs or cats; excessive heat should be avoided, however, because fibrinogen precipitation or autoagglutination may then occur. We typically do not warm up blood or pRBCs prior to administration. The administration set should have a filter in place (Travenol Laboratories, Deerfield, IL) to remove clots and other particulate matter, such as platelet aggregates. The blood is usually administered via the cephalic, saphenous, or jugular veins. To prevent bacterial contamination, blood should not be exposed to room temperature during administration for longer than 4 to 6 hours (i.e., blood is considered to be contaminated if it is at room temperature for more than 6 hours). If necessary, two smaller volumes of blood can be administered in succession. Blood should never be administered with lactated Ringer’s solution because of the calcium chelation with citrate and consequent clot formation that may occur. Normal saline solution (0.9% NaCl) should be used instead.