PRACTICAL BLOOD TRANSFUSION IN THE DOG & CAT, AND ALTERNATIVE BLOOD PRODUCTS

Trudi McAlees BSc BVSc MACVSc FACVSc
Animal Accident and Emergency, Essendon, VIC

WHAT BLOOD PRODUCTS HAVE WE GOT?

- Animal blood is an animal remedy and as such must be licensed if it is to be sold. To my knowledge, there are two licensed commercial sources of canine blood products in Australia. Packed red blood cells and fresh-frozen plasma are available from the University of Melbourne’s Canine blood bank. Caniplas™ (fresh frozen plasma) is available from some drug wholesalers. Plasma is sometimes further divided into cryoprecipitate (containing von Willebrand’s factor, fibrinogen and factors VIII, VIIIc, XIII) and cryosupernatant (non-labile clotting factors e.g. II, VII, IX, X and plasma proteins) by blood banks.
- Unfortunately, there is no commercial source of cat blood available in Australia at this time.
- Fresh whole blood can be sourced from clinic donors for in-house use. You can also make your own packed red cells and fresh plasma for in-house use if you have the need and the equipment.

WHAT BLOOD PRODUCTS OR ALTERNATIVES MIGHT WE GET?

- **Albumin solutions: human or canine:**
  Canine serum albumin and human serum albumin (HSA) products are available overseas. Human serum albumin is available for use in human medicine in Australia, though veterinary practices are unable to access this product for use in dogs.
  Albumin is used as a colloid for resuscitation and in hypoalbuminaemic patients. Immediate mediated reactions, both immediate and delayed, have been reported in dogs treated with HSA. Human trials have failed to show improved outcome in patients treated with HSA for fluid resuscitation or hypoalbuminaemia.

- **Platelets**
  Severe thrombocytopenia or more rarely, thrombocytopenia can result in spontaneous bleeding. The most commonly seen cause of this in dogs is immune mediated thrombocytopenia. Platelet transfusions are not generally indicated in these patients as the transfused platelets survive only a matter of minutes or hours in the recipient. This may be long enough to provide short-term haemostasis in life-threatening situations such as intracranial haemorrhage.
  Fresh whole blood is currently the only source of platelets available in Australia.
  Fresh platelet concentrates cryopreserved and lyophilised (freeze dried) canine platelets are available in the US. The platelets have decreased activity and a shorter lifespan than freshly harvested platelets.

- **Haemoglobin based oxygen carriers**
  HBOC’s, such as Oxyglobin® have been developed. This product has never been for sale in Australia, and has been out of production. Recently, the media reported that an HBOC was sourced directly from the US manufacturer and used at the Alfred Hospital in Melbourne to save the life of a woman who refused blood transfusions for religious reasons.
  Oxyglobin® had several advantages: it provided effective temporary oxygen carrying ability without the need for cross matching or sourcing blood products; it had a long shelf life; it could be used across different species. Its use is not without issues however. It causes marked discolouration of plasma meaning many diagnostic blood tests cannot be used for several days. It is a potent small particle colloid and can easily result in volume overload, especially in normovolaemic anaemic cats.

WHEN IS A TRANSFUSION INDICATED?

The main indications for transfusion in small animal practice are anaemia and disorders of coagulation. Other indications include specific plasma component deficiencies and hypoproteinaemia.

When do we give a transfusion of red blood cells or fresh whole blood?

Clinically, we care about anaemia or a low packed cell volume (PCV) because it represents a decrease in the oxygen carrying capacity (CaO₂) of blood and therefore in decreased delivery of oxygen (DO₂) to the tissues.

In health, there is an excess of oxygen delivered to the tissues in the arterial blood. The cells extract what they need to leaving up to 75% of the oxygen to be returned to the circulation in venous blood. The proportion of delivered oxygen that is used in the tissues is referred to as the oxygen extraction ratio. Normal is about 25%. The tissues are easily able to increase this to a maximum of 50% e.g. during exercise or when the amount of oxygen being delivered is decreased. If oxygen use increases or delivery declines further, the tissues must start to metabolise anaerobically and accrue an oxygen debt.
Figure 1: Effect of haematocrit on viscosity and oxygen delivery

The PCV or haematocrit not only determines DO₂, it is also the main determinant of blood viscosity. Raising haematocrit simultaneously increases oxygen content and viscosity. Decreasing PCV and therefore viscosity will increase blood flow as long as cardiac output is maintained and there is no vasoconstriction. Decreasing viscosity has the additional advantage of decreasing cardiac afterload and augmenting stroke output.

The upshot of all this is, that because of compensatory changes in CO and oxygen extraction, progressive anaemia will not impair tissue oxygenation until the haematocrit reaches a dangerously low level – probably less than 15% in non-critically ill dogs and people, lower in cats.

Transfusion medicine is a very inexact art. To quote Marino, “transfusing red blood cells to correct anaemia is one of the most fickle and arbitrary interventions in critical care medicine”¹.

In most cases, patients are transfused to a number: a haematocrit or haemoglobin value that has been chosen as the lowest “safe” number. The number is not usually chosen for that particular patient, or even for that disease process, but by the hospital or the attending clinician. And that is if there is even a consistent number: few human ICUs have standardised transfusion practices. Transfusions are often given to people without a documented evidence of need or benefit in the patient. I suspect that this is not quite such a problem in veterinary medicine as we have to source the blood and then justify the cost of the transfusion to the owners.

Transfusions are not without risk, have been shown to independently worsen outcome²,³ and, of special significance in veterinary medicine, contribute significantly to the cost of treatment.

Several questions need to be answered when we consider transfusing anaemic patients:

1. Is a low haematocrit harmful to the patient?
2. What is the lowest tolerable haemoglobin concentration in this patient?
3. Will blood component transfusion benefit the patient?
4. What harm will potentially be done to the patient by a transfusion?

A reasonable indication for the transfusion of red blood cells is to augment the oxygen carrying capacity of the blood, but:

- There is a lack of data defining the haemoglobin concentration in humans and in animals that hinders adequate oxygen delivery and initiates tissue hypoxia.
- Mild to moderate anaemia does not compromise oxygen delivery as long as intravascular volume is maintained. Studies show that the oxygen extraction ratio (VO₂/DO₂) progressively increases as a compensatory response to haemodilution. Isovolaemic haemodilution to a haemoglobin concentration of 5 g/dL in resting humans does not produce evidence of inadequate systemic oxygen delivery or adverse clinical effects.
- A Canadian trial (Transfusion Requirements In Critical Care, the TRICC study) demonstrated that a restrictive transfusion strategy (transfusion trigger: haemoglobin concentration of 7 to 9 g/dL) was at least equivalent if not superior to a liberal transfusion strategy (transfusion trigger: haemoglobin concentration of 10 to 12 g/dL) in critically ill patients⁴. The average number of transfusions was reduced by 54% when the lower threshold was used, and 33% of the patients in the restrictive group did not require transfusion. The 30-day mortality rate was similar in both groups. In younger patients with lower illness severity scores, the mortality rate was significantly lower for the restrictive transfusion group than for the liberal group.
- PCV is in itself variable: plasma volume has a huge influence on haematocrit. In humans, the PCV increases by 4.1% in healthy volunteers when they go from a supine to a standing position and the plasma volume decreases by 420 ml. This is equivalent to a unit of blood!

The optimal haemoglobin concentration in critical illness is unknown. Patients with cardiac disease appear to require a higher haemoglobin concentration i.e. 10 to 12 g/dL than patients with normal cardiac function. Critically ill patients have a changing plasma volume due to fluid shifts, IVF therapy and haemodynamic instability. The haematocrit is thus very variable and an unreliable indicator of oxygen delivery and the requirement for a transfusion.
So, when is a transfusion needed?
The transfusion trigger may be difficult to determine, especially in acute blood loss situations because PCV and TP do not accurately reflect the extent of blood loss until intravascular volume is normalised. Also, hypoperfusion contributes to the hypoxia. Transfusion therefore should be based on the status of the patient not just the PCV.

Information we can use to decide whether a blood or red cell transfusion is indicated includes:

- **Goal PCV:**
  - Flawed, unreliable but the “number” we use and rely on.
  - Less than 15% likely to be impacting on DO₂
  - Ideally > 20% in a dog with cardiac insufficiency?
  - Preferably > 25% prior to surgery in the dog, > 18% in the cat

- **Cardiac output:**
  - Increased viscosity when the PCV is much over 30% can decrease CO and cancel the benefit of the increased haematocrit.
  - Heart rate is often normal at rest in anaemic animals. Checking HR after a gentle walk outside can give us information about the adequacy of DO₂ with exercise. A slight increase in HR is appropriate after movement, especially if the animal is a bit painful. If the HR is markedly increased after a walk, inadequate DO₂ is one differential.

- **Systemic oxygenation:**
  - Lactate: inadequate DO₂ will result in anaerobic metabolism and increased lactate.
  - Base deficit: an indicator of anaerobic metabolism.
  - Oxygen utilisation, VO₂: clinically can be approximated by the arterial-venous oxygenation difference i.e. SaO₂ (from the pulse oximeter) – SvO₂ (from venous blood gases). Normal is about 25%, maximal OER is about 50%. If the OER is approaching 50%, it is markedly increased and VO₂ is about to become “supply dependant”.

In general, dogs with a PCV less than 20%, a PCV less than 25% due to acute loss or ongoing haemorrhage require blood products. In cats, normal PCV is a lot lower so they are often clinically stable with a PCV of 15% or less. Animals with acute loss of 20% or more of their blood volume will benefit from either whole blood or packed red blood cell transfusion + crystalloid fluid administration.

**When do we give a transfusion of plasma?**
Plasma is indicated to treat a coagulopathy and in some cases of hypoproteinaemia. Fresh whole blood is also a good source of clotting factors and contains protein.

Stored whole blood (up to 4 weeks) will still contain some clotting factors and contains protein.

- Animals with an ACT or APTT greater than 150% of normal (i.e. longer than 180 seconds in most cases) are at risk of spontaneous haemorrhage.
  - Dogs that present with a coagulopathy, usually due to anticoagulant rodenticide intoxication, require one unit of whole blood (400 – 500 ml) or plasma (approximately 200 – 250 ml) per 10 – 20 kg. I will usually administer 1 unit per 20 kg then recheck clotting times.
  - Plasma transfusions will increase serum albumin by approximately 5 g/dL for every 20ml/kg of plasma given. That means that a 10 kg dog will have an increase in serum albumin of 5 g/dL per unit of plasma; a 30 kg dog an increase of only 1 – 2 g/dL.

**PRACTICAL TIPS: HOW DO WE GIVE TRANSFUSIONS?**
Points to remember:

- Have a concrete reason for the transfusion. Blood products are not “tonics” or “cure alls” nor should they be used prophylactically.
- Premedication with antihistamine? To reduce the incidence of acute hypersensitivity reactions? No clinical trials have yet been published to prove that this decreases transfusion reactions.
- I do not use steroids in my patients unless they are indicated for another reason. Steroids have not been shown to decrease the incidence of reactions and even one shot of dexamethasone in a hypovolaemic dog can cause profound GIT ulceration.
- Once a blood pack has had the administration set put into it, the transfusion should be completed within 4 hours to minimise the risk of bacterial growth in the blood product.
- Adhere to strict asepsis: blood is used as a microbiological culture medium!
- Use a blood administration set with a filter.
- Do not administer blood products with calcium containing fluids, hypo- or hypertonic solutions.
- Plasma has not been shown in human clinical trials or in animals to improve the outcome of pancreatitis or parvovirus patients unless they are coagulopathic or hypoalbuminaemic.
**Monitoring during a transfusion**

Start the transfusion at a low rate i.e. 1 ml/kg /hour. Monitor heart rate, temperature, and respiration rate every 5 minutes initially. Ideally the animal should also be on continuous ECG monitoring to detect any arrhythmias which may be the first sign of a transfusion reaction. If there are no problems in the first 15 minutes, the rate of product administration may be slowly increased up to a maximum rate of 10 ml/kg/hour. Continue monitoring closely for the first 1/2 an hour (cage side monitoring), then check every 15 - 30 minutes while remaining in the room with the animal at all times.

In an emergency situation, blood may be given more rapidly, though the faster products are administered, the greater the chance of a reaction.

**Is Crossmatching Necessary?**

Crossmatching assesses the effect that recipient serum antibodies will have on the donated red blood cells (major crossmatch) and the effect that donor serum will have on the recipient red blood cells (minor cross match).

Dogs have 8 different blood groups, dog erythrocyte antigens (DEA). Not all of them are important when it comes to transfusion reactions. DEA 1.1 is the most important cause of transfusion reactions, with 1.2 second and 7 also playing a role. Dogs have a low incidence of naturally occurring antibodies to red cells and are unlikely to react strongly to a first transfusion. So, if a dog has not had a transfusion before, and has not had puppies, a cross match is probably not strictly necessary unless the dog is likely to require repeated blood transfusions e.g. immune mediated haemolytic anaemia. Any transfusion given more than 4 days after the first one should be cross matched.

Cats do have naturally occurring alloantibodies and so should always be blood typed or cross matched prior to a transfusion. Cat AB blood typing cards are available commercially. You can purchase these cards for use in your practice, or send blood to a lab for typing.

There are 3 blood groups in cats:
- **A** (75 - 95% of cats): If a type A cat receives type B blood, the red cells will be destroyed within 2 days.
- **B**: If a type B cat receives type A blood, an acute, often fatal transfusion reaction occurs. The red cells will survive a maximum of 1 hour.
- **AB** (<0.5% of cats): Type AB cats have no alloantibodies. They should ideally receive type AB blood otherwise they should get type A blood. If they are given type B blood, the donor blood will react strongly against the A of the recipient and a “graft vs. host” reaction will occur.

There is also the newly discovered Mik antigen. A Mik –ve cat can have naturally occurring anti-Mik alloantibodies which can result in an acute haemolytic transfusion reaction after an AB-matched blood transfusion if the donor cat is Mik +ve.

Rapid Vet-H major Crossmatch kits for in-house cross matching in cats and dogs without the need for cell washing, test tubes, incubations, microscopes etc. have been available in the USA for several years but I have not seen them in Australia yet.

**Dose of blood to give:**

Packed red blood cells and fresh frozen plasma are administered at 10 – 15 ml/kg, whole blood at 20 – 25 ml/kg. Blood products are usually administered slowly, over 2 – 3 hours, to reduce the chance of reactions and volume overload. In an emergency situation it may be necessary to administer them as a rapid IV bolus i.e. over 10 – 15 minutes.

- **Cats**: 50 – 60 ml is usually all we have. Remember that whole blood is a fluid and that in normovolaemic but anaemic cats, fluid overload is a very real concern.
  
  Volume to give = Bwt (kg) x 66 x (goal PCV – recipient PCV)/donor PCV

- **Dogs**: Rule of thumb: 10 ml/kg PRBCs or 20 ml/kg whole blood will increase PCV by about 10%
  
  In a 20 kg dog with a PCV of 10%, give 15 x 20 = 300 ml PRBCs to raise the PCV to 25%.
  
  Volume to give = Bwt (kg) x 85 x (goal PCV – recipient PCV)/donor PCV

  In a 20 kg dog with a PCV of 10%, give 20 x 85 x (25-10)/70 = 364 ml PRBCs to raise the PCV to 25%.

**Cat blood transfusions**

**Donor:**
- Young, healthy, nice...
- 4.5 kg lean body weight
- PCV > 30%, ideally > 35%, before blood collected
- FeLV, FIV, *M haemofelis* negative

**Anaesthetic:**
- Minimal CV depression and vasodilation

---

*Small Animal Medicine and Feline Chapters*
• IV fluids to replace volume of blood taken? Blood volume in a cat is around 66 ml/kg. Up to 20% of blood volume (60 ml in a 4.5 kg cat, 52ml in a 4 kg cat) can be donated provided IV fluids are administered.
• Monitored closely

My technique:
• Ideally three people:
  1. Monitors the donor
  2. Gains IV access and holds the needle steady
  3. Draws back on syringe, rolling syringe as blood is collected to mix
• Materials for blood collection: 60 ml syringe + extension set primed with 2ml of 1000 U/ml heparin + 18g needle.
• Materials for blood administration: 100ml or 250ml bag of saline spiked with and emptied via a blood administration set
• Method:
  1. Collect blood into pre-prepared syringe, remove the extension set.
  2. Inject blood into the prepared saline bag using a clean 16g needle
  3. Administer the blood either via a pump or gravity through the blood admin set that you drained the saline bag with.
