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Feline Blood Types and Blood Transfusions
PART II: Blood Collection and Transfusion

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The administration of blood to feline patients can be a lifesaving procedure. The previous article focused on feline blood types, the methods of blood collection and administration as well as donor selection. This article will discuss the practical aspects of blood collection and administration.

BLOOD COLLECTION

Blood collection without sedation of blood donors has been reported and, interestingly, conscious donors were no more likely to result in inadequate blood donation volumes than sedated cats in a retrospective study (Doolin et al., 2017). Signs of donor cat anxiety or movement during collection are more frequently reported during conscious donations and so, in practice, sedation is usually administered. The combination of 5mg/kg ketamine and 0.25mg/kg midazolam, mixed in the same syringe and given intramuscularly, will last 20-30 minutes. Alternatively, 2mg/kg ketamine and 0.25mg/kg midazolam or diazepam can be given intravenously. An additional sedation containing the same sedation dose should be prepared in a second syringe, and this can then be given intravenously in 0.05-0.1ml increments to prolong sedation, if necessary. Additional sedation protocols using butorphanol and alphaxalone or tiletamine and zolazepam have also been described (Granfone et al., 2018, Spada et al., 2015). Crystalloid fluid replacement therapy should be administered to the donor immediately after blood collection, with 2-3 times the blood volume that was collected being given over 1-2 hours.

Blood collection equipment

All necessary equipment for blood collection should be ready before sedation of the donor cat (Box 1). Ideally, at least three people should be present: a phlebotomist, a handler and one or more assistants.

Preparation of blood collection equipment

Before blood collection begins, the collection equipment needs to be prepared. Usually, up to 50ml of blood is collected, necessitating, for example, 5 x 10 ml syringes to be prepared. However, it is prudent to prepare a total of 6 x 10 ml syringes in case a problem, such as the formation of a clot, occurs in one of the syringes. This allows just that syringe and its content to be

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discarded rather than the full donation. Some phlebotomists use 3 x 20 ml syringes instead, however this means more blood may be discarded should a problem arise in one of the syringes.

Box 1: Necessary equipment for open blood collection

- Clippers to remove fur from jugular area (not pictured)
- Swabs with surgical scrub
- Spirit
- A bag of ACD-A
- 6 x 10 ml syringes
- 12 x 21 G ⅝-inch needles, used to draw ACD-A from the bag, then to cover each syringe hub before and after blood collection
- A 3-way tap
- A 21 G ⅝-inch butterfly needle
- A plain 150 ml blood collection bag
- 6 x 19 G 1.5-inch needles, used to transfer the blood slowly from each syringe to the collection bag
- Blood giving set with filter, used to administer the blood. If not available, the blood can be administered in a syringe on a syringe driver, using a syringe filter.
- Artery forceps

The first assistant draws around 1.3ml of Anticoagulant Citrate Dextrose Solution, Solution A, U.S.P. (ACD-A) into each of the 10 ml syringes, covering each syringe hub with a needle immediately. Following this, the first syringe is attached to a 3-way tap, along with either an extension set and needle or a butterfly needle, depending on the phlebotomist's preference. ACD-A is then flushed through the equipment, ready for the collection of the first 10ml of blood from the donor (Image 1).

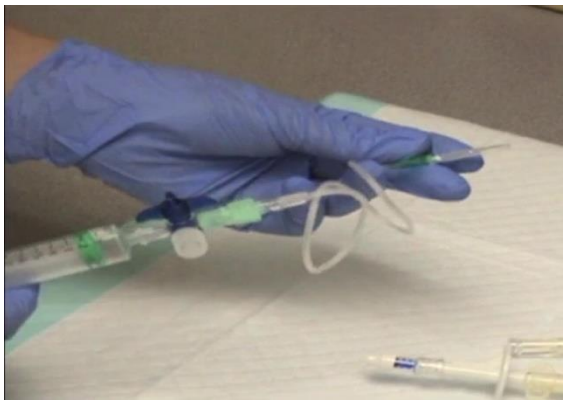

Image 1: Preparation of blood collection equipment by drawing 1.3ml ACD-A into a 10ml syringe, then attaching a 3-way tap, along with a butterfly needle, and flushing it through the equipment.

The long extension tubing of the plain blood bag should be tied off and clamped to prevent blood running down its length. This tube is designed for direct blood collection into the bag, but the length and diameter make it difficult to achieve a satisfactory flow of blood. In the Feline Centre, we prefer not to use this and collect via syringes instead. Blood is later injected directly into the bag via the port using 19 G needles to prevent damage to the red blood cells (RBCs).
Alternatively, small (50-150mls) dry blood collection bags are available (Jorgensen, distributed in the UK by Kruuse Ltd), enabling collection of blood from the donor directly into the collection bag, rather than into a syringe.

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Anticoagulant must be added to these bags and the collection system must be flushed through with anticoagulant before use.

Preparation of the donor cat

Before blood collection begins, an intravenous catheter (22 G), T-connector, tape, bandage material and heparinised saline for flushing should be prepared. An intravenous catheter is placed in the cephalic vein of the donor ideally before or immediately after sedation (Image 2). An ophthalmic lubricant should be applied to the eyes during sedation to help prevent corneal ulceration.

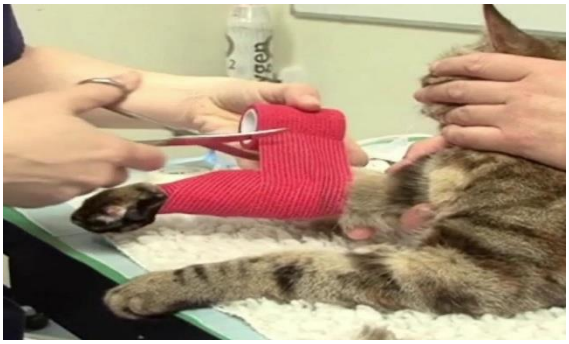

Image 2: Placement of intravenous cephalic catheter before or after donor sedation will allow for additional sedation to be administered, if necessary, during blood collection. It is also used to administer crystalloid fluids immediately after blood collection.

The donor is positioned according to the preference of the phlebotomist; blood collection can be achieved in dorsal (Image 3), sternal or lateral recumbency. After positioning the donor, the handler holds both front legs back, allowing the neck to extend for optimal visualisation of the jugular veins, and the area is clipped of hair on the preferred side to be used. A blanket or thick towel placed under the donor cat's neck can help with visualisation of the jugular vein. The area is then prepared aseptically first with surgical scrub then spirit.

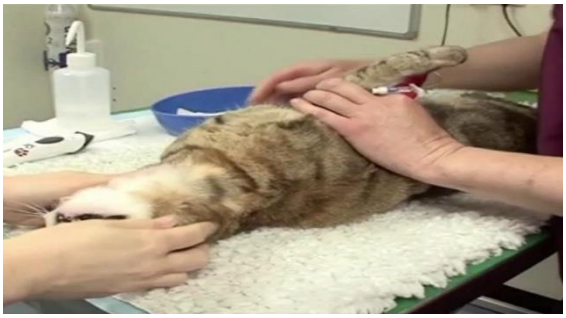

Image 3: Donor cat positioned in dorsal recumbency, with the handler holding both front legs back and the neck extended for optimal visualisation. Careful preparation of the jugular area ensures optimal visualisation and minimises infection risk.

Blood collection technique

Surgical gloves should be worn by the phlebotomist to maintain sterility and reduce infection risk (Image 4).

Image 4: Placement of sterile gloves should always be undertaken before blood collection begins.

The phlebotomist holds the prepared butterfly needle in one hand and the cat's head in the other hand. The handler raises the jugular vein by applying pressure at the thoracic inlet, away from the sterile area, and the first assistant holds the attached syringe. The phlebotomist inserts the butterfly needle into the jugular vein to its hub and holds the needle steady in position (Image 5).

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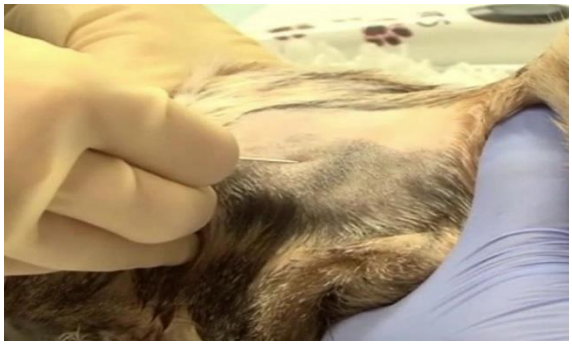

Image 5: Insertion of butterfly needle into the left jugular vein of the donor cat.

The first assistant then begins to withdraw the blood slowly by applying suction to the syringe. Blood should flow easily, without too much pressure on the syringe. If this is not the case, the phlebotomist will need to readjust the needle before the first assistant starts applying gentle suction again, collecting blood into the syringe (Image 6).

Image 6: Withdrawal of blood from the jugular vein of the donor by the first assistant applying gentle suction to the syringe.

When the first syringe is filled to 10ml, the first assistant carefully closes the 3-way tap to the donor cat, disconnects the full syringe from the 3-way tap and hands it to the second assistant who immediately places a needle or a bung on its end. The second assistant then passes the next prepared syringe containing ACD-A following removal of the needle or bung, ready to be attached to the 3-way tap. The process is repeated until all five syringes are filled with blood. Following withdrawal of the needle, the handler should place pressure onto the jugular vein.

Blood collected in an open system should ideally be used immediately (within 4 hours), although studies have described storing blood successfully in the fridge for up to 21 days (Hourani et al., 2017). ACD-A acts as a preservative to enable storage of the blood should the transfusion not go ahead or if the full volume of collected blood is not required. Citrate phosphate dextrose adenine (CPDA) is an alternative anticoagulant which is available and can be used at the same concentration as ACD-A. CPDA may allow longer storage of blood before use (see below). Heparin anticoagulant has also been used (625units per 50mls of blood), but blood collected into heparin must be used immediately. Additionally, heparin may increase microthrombi formation by stimulating platelet aggregation.

BLOOD TRANSFUSION

Blood collection without sedation of blood donors has been reported and, interestingly, conscious donors were no more likely to result in inadequate blood donation

Amount to be transfused

The amount of blood that the recipient needs can be estimated using various formulae but a recent study (Reed et al., 2014) found that the following simple formula was the most reliable:

Volume of blood to be transfused (ml) = 2 x weight of patient (kg) x (desired PCV % increase)

This equates to 2 ml/kg of whole blood increasing a patient's PCV by 1%.

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The target PCV does not have to be within the reference interval for PCV as this is often too high a target. As 50-60 ml of blood is usually collected from a donor, the desired PCV of, for example, 20% may still not be reached in the recipient. However, even a modest increase in PCV can make a huge clinical difference to the anaemic recipient.

The total blood volume in cats is approximately 66ml/kg, so a 4.5kg cat has around 297ml of blood. Collection of 20% of blood volume should not result in clinically significant anaemia and can be done safely, ensuring crystalloid intravenous fluids are administered to guard against hypovolaemia which could develop with rapid blood collection. Collection of less than 10% blood volume from a donor does not require crystalloid replacement therapy. A 4.5kg cat can therefore safely donate around 60ml of blood, equivalent to 20% of its blood volume.

Other formulae include the blood donor PCV in calculations to determine how much blood to collect (Reed et al., 2014). Unfortunately, in cats the expected PCV increase following whole blood transfusion is not often realised. This may be because significant decreases in haematological parameters (such as haemoglobin, RBCs) are found in donated whole blood units compared to the corresponding blood sample collected from the donor before blood is collected for the transfusion (Spada et al., 2017). This can be partly due to the dilution of the RBCs in the unit as a result of the anticoagulant used or if intravenous fluid therapy is given partway through blood collection.

Blood transfusion technique

As previously mentioned, in the Feline Centre we prefer to collect blood via syringes and inject it directly into a plain blood bag. This allows the insertion of a blood filter giving set into the blood collection bag to enable safe and easy intravenous transfusion of the blood to the patient (Image 7).

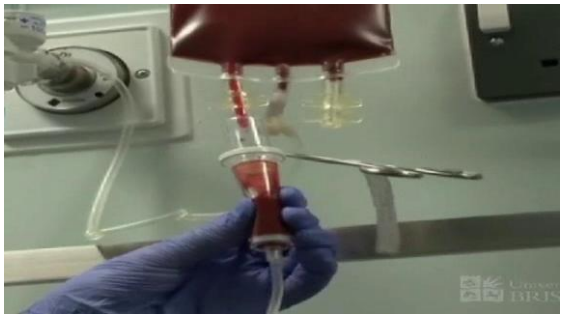

Image 7: Prepping of blood filter giving set before the start of blood transfusion.

If blood has been collected directly into a blood collection bag, the bag can be connected to a blood filter giving set for administration. Filters are required to reduce the risk of microthrombi entering the circulation. Microthrombi can form secondary to infusion pump damage of RBCs. A syringe driver may be used instead if blood was collected into a 20ml syringes, adding a blood filter onto the syringe to prevent microthrombi (Image 8).

Image 8: A blood filter needs to be used if administering blood using a syringe driver.

Blood is typically administrated via the cephalic vein. Intraosseous administration via the proximal femur is also effective if peripheral veins are not available. The blood should be gently warmed to 37oC before administration not only to prevent hypothermia and vasoconstriction in the recipient, but also to increase blood viscosity. This can be done by

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immersion in a warm water bath within a sealed bag. Take care to avoid overzealous heating as this can result in haemolysis and clotting.

Blood must not be given through a catheter that contains, or has contained without saline flushing, calcium-containing fluids (e.g. Hartmann's / Lactated Ringer's, some colloids). Care must be taken to ensure that the catheter has been flushed with 5 ml of saline before blood administration. It is prudent to connect the blood filter giving set onto a T-connector instead of directly on the intravenous catheter to decrease the likelihood of catheter dislodgement during the blood transfusion (Image 9).

Image 9: Connecting the blood filter giving set onto a T-connector instead of directly on the intravenous catheter will make catheter dislodgement less likely during the blood transfusion.

The blood should be given at an initial rate of 0.25-0.5ml/kg/hour over the first 30 minutes with the recipient observed for adverse reactions. The rate can then be increased to 1ml/kg/hour for a further 30 minutes, then continued at the required rate (Image 10). In normovolaemic patients, care should be taken not to administer the remaining blood too quickly. In hypovolaemic patients, the rate of administration can be increased more quickly; maximum rate is 22ml/kg/hour for emergencies, but it is prudent not to exceed a rate of 10ml/kg/hour. In patients with chronic severe anaemia as a result of renal disease or patients with cardiac disease there is a higher risk of volume overload, therefore a rate of 2ml/kg/hour should be maintained. Indeed, cats with a PCV ≤ 18% were shown to have evidence of volume overload on echocardiography (Wilson et al., 2010). These cats are susceptible to the development of congestive heart failure due to increased intravascular volume; this occurs as a result of the haemodynamic compensatory responses that occur with chronic severe anaemia. In all cases, blood transfusion should be completed within 6 hours of start of administration to minimise the risk of bacteraemia.

Image 10: Initial rate should be 0.25-0.5ml/kg/hour over the first 30 minutes, 1ml/kg/hour for a further 30 minutes, then continued at the required rate to ensure the entire volume is administered within 4-6 hours from the start of the blood transfusion.

Anaemia is the most common indication for blood transfusion in cats. Whole blood is usually administered as described above. However, if packed RBCs are available, these are the treatment of choice for normovolaemic anaemic cats. Packed RBCs can be obtained by removing plasma from collected blood. Blood bank centrifuges are not commonly available in veterinary practices, so removal of plasma can be achieved by letting the RBCs sediment in refrigerated whole blood for 6 hours and then

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removing the supernatant plasma. Packed RBCs can be resuspending in saline (or another non-calcium containing crystalloid) before administration. The plasma can be stored frozen for several months for future use. To enable easy aseptic preparation and separation of packed RBCs and plasma, transfer blood bags are available from Kruuse Ltd to allow collection of blood components from whole blood collection bags. More recently, feline blood products have become available from the Animal Blood Bank that is based in Portugal (http://bsanimal.co.uk).

Blood transfusion reactions

All cats receiving blood should be monitored closely and continuously for signs of transfusion reactions. Vital signs and demeanour should be recorded. Plasma and urine can also be evaluated for the presence of haemoglobin. Vomiting may occur as a non-specific finding but has also been reported when blood is administered too rapidly and in association with haemolysis. Clinical signs of a transfusion reaction generally depend on the amount of blood transfused, the type and amount of antibody involved in the reaction, and whether the recipient has had previous sensitisation. The incidence of transfusion reactions varies in different studies and has been reported to occur in 1% of cats by Weingart et al (2004) and in 23% of cats by Sylvane et al (2018). In this study, almost all the reactions were febrile non-haemolytic transfusion reactions, which are less serious than haemolytic reactions.

Types of transfusion reactions and signs are listed in Table 1. Acute reactions typically occur within minutes to hours of starting the transfusion but can also occur up to 48 hours after the end of the blood transfusion. Immunological acute haemolytic anaemia arises when alloantibodies in the recipient's plasma destroy transfused erythrocytes, particularly in type B cats given type A blood. Further information on this can be found in the first part of the Blood Transfusion series.

Table 1: Classification of Transfusion Reactions

Immunological

Acute
- Haemolysis
- Acute hypersensitivity
- Platelet sensitivity
- White blood cell sensitivity

Delayed
- Haemolysis
- Immunosuppression
- Neonatal isoerythrolysis

Non-immunological

Acute
- Pretransfusion haemolysis of donor RBCs
- Circulatory volume overload
- Bacterial contamination of blood
- Others e.g. citrate toxicity, hyperammonaemia, acidosis, hypothermia, pulmonary embolism

Delayed
- Transmission of infectious agents
- Haemosiderosis

Acute hypersensitivity reactions are mediated by IgE antibodies and arise due to recipient antibodies to foreign proteins given in the transfusion. Severe intravascular haemolytic reactions may occur within minutes of the start of the transfusion, causing haemoglobinaemia, haemoglobinuria, disseminated intravascular coagulation and clinical signs of shock. Extravascular haemolytic reactions usually occur later and will result in hyperbilirubinaemia and bilirubinuria. Signs of transfusion reactions are listed in Table 2.

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Non-immunological transfusion reactions can arise due to abnormal handling or storage of blood before transfusion leading to RBC haemolysis or bacterial contamination. Sepsis can induce non-immunological haemolysis in the patient. Over aggressive or rapid transfusion of blood can lead to circulatory overload, particularly in cats with renal or cardiac insufficiency. Signs include dyspnoea and tachypnoea and can progress to pulmonary oedema. Management involves cessation of the transfusion, diuretic treatment and oxygen support. Citrate in blood products chelates calcium and following transfusion the citrate usually undergoes rapid hepatic metabolism. However, in patients with hepatic disease, hypocalcaemia can develop due to citrate overload with rapid administration of blood. Muscle tremors and cardiac abnormalities may be seen, and calcium treatment is required. The administration of cold blood products can lead to hypothermia, particularly in young cats, and is avoided by prewarming the blood before transfusion.

Table 2: Signs of Transfusion Reactions

- Urticaria
- Pyrexia
- Restlessness
- Vocalisation
- Vomiting
- Diarrhoea
- Change in respiratory rate with/without dyspnoea
- Change in heart rate with/without change in rhythm
- Weak pulses
- Hypotension

Termination of the transfusion, glucocorticoids, antihistamines and/or adrenalin may be required as treatment (Table 3).

Table 3: Procedures in cases of suspected transfusion reaction

- Stop the transfusion immediately; record volume infused and rate of infusion (do not discard the blood, line or fluids)
- Start cardiopulmonary resuscitation if necessary
- Examine the donor blood for haemolysis by spinning a microhaematocrit tube and looking for haemoglobinaemia
- Examine the recipient for haemolysis by spinning a microhaematocrit tube and looking for haemoglobinaemia
- Consider starting intravenous fluid therapy, especially in cases of severe intravascular haemolysis in order to avoid renal damage
- Consider treatment with glucocorticoids (e.g. hydrocortisone 2-4 mg/kg IV or IM), antihistamines (e.g. diphenhydramine 1 mg/kg IV or IM), and/or adrenaline (20 mcg/kg of a 1:10,000 solution (100 mcg (0.1mg) per ml) IV)
- Consider diuretic treatment and oxygen support in cases of pulmonary oedema due to volume overload; thoracic imaging and/or echocardiography may be indicated
- Bacterial culture of a sample of the donor blood unit may be required if infection or contamination is suspected
- Antipyretics (e.g. meloxicam) may be indicated in some cases. Assess renal function prior to administration.

Recipient antibody against donor platelet or white blood cells can result in self-limiting febrile non-haemolytic reactions. Antipyretics may be required in these cases. Pyrexia can also be seen with haemolysis or sepsis; hence these

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conditions should be ruled out cats in developing pyrexia during or after a transfusion.

Should I give canine blood to a cat?

Xenotransfusion is the act of transfusing blood from one species into another species, in this case from a dog to a cat. There are published reports of canine blood administration to cats in emergency situations where a rapid improvement in clinical signs was seen (Bovens and Gruffydd-Jones, 2013, Oron et al., 2017). The effect of the xenotransfusion is short-lived as the transfused canine RBCs only survive for an average of 4 days (Clark and Kiesel, 1963). This is most likely as the result of haemolysis, with more recent studies suggesting that antibodies are produced quicker than the usually quoted 4 days (Hourani et al., 2017). A fatal haemolytic transfusion reaction can occur if canine blood is given to a cat that has received canine blood within four days or less. It had been previously suggested that first transfusions were relatively safe (Bovens and Gruffydd-Jones, 2013), however a recent report described acute haemolytic transfusion reactions in two cats given canine blood for the first time (Euler et al., 2016), thereby disputing this.

Xenotransfusions should generally be avoided and only be performed as a potential life-saving measure when it is not possible to obtain compatible feline blood, either from a local donor or a blood bank. The risks from this short-term benefit need to be justified by a potentially good long-term outcome (e.g. whilst therapy takes effect), and only considered in a cat that has never received canine blood before. The owner must also fully understand the risks involved.

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