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SPECIAL ARTICLE

2021 ISFM Consensus Guidelines on the Collection and Administration of Blood and Blood Products in Cats

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Samantha Taylor
BVetMed(Hons), CertSAM, DipECVIM-CA, MANZCVS, FRCVS
*Panel Chair**
International Society of Feline Medicine, Tisbury, UK

Eva Spada
DMV, PhD
Veterinary Transfusion Research Laboratory (REVLab), Department of Veterinary Medicine (DIMEVET), University of Milan, Italy

Mary Beth Callan
VMD, DACVIM (SAIM)
Department of Clinical Sciences and Advanced Medicine, School of Veterinary Medicine, University of Pennsylvania, USA

Rachel Korman
BVSc, MANZCVS (Internal Medicine), FANZCVS (Feline Medicine)
Cat Specialist Services, Underwood, Queensland, Australia

Ellie Leister
BVSc(Hons), FANZCVS (Emergency & Critical Care)
Pet Intensive Care Unit, Underwood, Queensland, Australia

Paulo Steagall
MV, MSc, PhD, Dipl ACVAA
Department of Clinical Sciences, Faculty of Veterinary Medicine, Université de Montréal, QC, Canada

Remo Lobetti
BVSc, MMedVet, PhD, DECVIM
Bryanston Veterinary Hospital, Johannesburg, South Africa

Mayank Seth
BSc(Hons), BVetMed(Hons), DACVIM, DipECVIM-CA, MRCVS
Dick White Referrals, Six Mile Bottom, UK

Séverine Tasker
BSc, BVSc(Hons), PhD, DSAM, DipECVIM-CA, FHEA, FRCVS
Bristol Veterinary School, University of Bristol, Langford, UK; and Linnaeus Group, Shirley, UK

*Corresponding author:
sam.taylor@icatcare.org

Practical relevance: Blood and blood products are increasingly available for practitioners to use in the management of haematological conditions, and can be lifesaving and therapeutically useful for patients with anaemia and/or coagulopathies. It is important for feline healthcare that donors are selected appropriately, and transfusions of blood or blood products are given to recipients that will benefit from them. Complications can occur, but can be largely avoided with careful donor management and recipient selection, understanding of blood type compatibility, and transfusion monitoring.

Clinical challenges: Feline blood transfusion, while potentially a lifesaving procedure, can also be detrimental to donor and recipient without precautions. Cats have naturally occurring alloantibodies to red cell antigens and severe reactions can occur with type-mismatched transfusions. Blood transfusions can also transmit infectious agents to the recipient, so donor testing is essential. Finally, donors must be in good health, and sedated as appropriate, with blood collected in a safe and sterile fashion to optimise the benefit to recipients. Transfusion reactions are possible and can be mild to severe in nature. Autologous blood transfusions and xenotransfusions may be considered in certain situations.

Evidence base: These Guidelines have been created by a panel of authors convened by the International Society of Feline Medicine (ISFM), based on available literature. They are aimed at general practitioners to provide a practical guide to blood typing, cross-matching, and blood collection and administration.

Keywords: Transfusion; plasma; xenotransfusion; transfusion reaction; blood type; cross-match

Introduction

Although feline blood transfusions are infrequently performed in primary care veterinary practice, they can be lifesaving.[1,2] Availability of donors has limited the utility of this technique, but with the growth of blood banks providing access to feline blood, the procedure may become more routine. It is important that veterinary practitioners select appropriate recipients and donors (or stored blood) and administer blood correctly and with monitoring to mitigate the risks.

These Guidelines are written to provide information for practitioners on blood types and cross-matching, indications for transfusion, donor management, recipient preparation, blood/blood product administration, and monitoring and potential complications.

Ethical considerations
ISFM have produced these Guidelines to improve the clinical approach to blood product collection and administration. However, therapy with blood products is not just a clinical procedure. There are important ethical considerations with respect to both the harvesting of blood from the donor and the long-term benefit to the recipient. See the Appendix on page 432 for further discussion.

Feline blood types

Alloantigens

Blood types arise due to genetically determined antigenic markers present on the surface of red blood cells (RBCs). Blood type antigens are alloantigens, as they exist in alternative (allelic) forms in different cats, and can induce an immune response when RBCs of one blood type are transferred to a cat with a different blood type.

One blood group system, the AB system, has been extensively defined in cats. Within the AB blood group system there are three blood type phenotypes, namely type A, type B and type AB:

- **Blood type A** is common. N-glycolyl-

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Table 1 Blood types reported in different geographical locations in different breeds of cat in published studies

Country/regional source of data (reference)	Breed	Number of cats	Type A %	Type B %	Type AB %
UK[3]	Non-pedigree	139	87.1	7.9	5.0
	British Shorthair	121	39.7	58.7	1.6
	Birman	24	62.5	29.2	8.3
	Persian	17	88.2	11.8	0
	Other pedigrees	45	77.8	6.7	15.5
UK[4]	Non-pedigree	105	67.6	30.5	1.9
	Siamese	13	100.0	0	0
	Other pedigrees	38	76.3	21.1	2.6
UK[5]	Bengal	100	100.0	0	0
Denmark[6]	Non-pedigree	105	98.1	1.9	0
	Persian	56	96.4	3.6	0
	British Shorthair	30	66.7	33.3	0
	Abyssinian	20	100	0	0
	Other pedigrees	33	90.9	9.1	0
Australia[7]	Non-pedigree	355	62.0	36.0	1.6
	Siamese	12	100.0	0	0
	Devon Rex	70	45.0	54.0	1.4
	British Shorthair	8	38.0	62.0	0
New Zealand[8]	Non-pedigree	245	70.6	13.9	0.8
France[9]	Non-pedigree	320	83.8	14.4	1.9
	Pedigree	37	89.2	10.8	0
Central Italy[10]	Non-pedigree	483	89.8	7.0	3.1
North Italy[11]	Non-pedigree	233	91.0	5.2	3.8
South Italy[11]	Non-pedigree	215	77.2	12.1	10.7
Italy[12]	Ragdoll	61	77.1	4.9	18.0

Blood type prevalence varies geographically, with type A being the most common worldwide.

neuraminic acid is the alloantigen on the RBC surface;

- **Blood type B** is less common overall, but common in some pedigree breeds (eg, British Shorthair, Birman, Devon Rex). N-acetylneuraminic acid is the alloantigen on the RBC surface;
- **Blood type AB** is rare. N-glycolylneuraminic acid and N-acetylneuraminic acid are the alloantigens on the RBC surface.

Blood type prevalence varies geographically (see Table 1). Type A is the most common worldwide and in some breeds 100% of cats are believed to be type A (eg, Siamese[4]). The prevalence of type B is much lower than type A but it has been reported to be as high as 36% in non-pedigree cats in Australia,[7] and some breeds can contain high numbers of type B cats (especially the British Shorthair[3,6]). Type AB is much less common. Blood typing is essential to avoid potentially fatal transfusion reactions.

Alloantibodies

In contrast to dogs, cats can possess naturally occurring alloantibodies against the 'foreign' (non-self) alloantigen that they are lacking. These alloantibodies will recognise the alloantigens of another cat. Kittens develop these antibodies at 6–8 weeks of age. In the UK, for example, over 70% of type A cats have anti-B alloantibodies,[13] which are mostly present at low concentrations, while all type B cats have anti-A alloantibodies, often present at high concentrations. In a report from the USA, all type A cats had anti-B alloantibodies.[14] Type AB cats never have alloantibodies to either type A or type B antigens. The reaction between the blood type alloantigens and any existing alloantibodies is observed during cross-matching of donor and recipient blood.

Blood typing is essential to avoid potentially fatal transfusion reactions.

Alloantibodies are responsible for potentially fatal blood transfusion reactions that can arise even when cats undergo their first blood transfusion, as they are already present in the cat's circulation, ready to destroy RBCs of a

Type-compatible blood

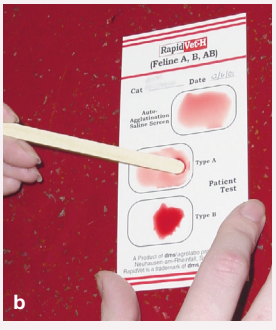
Donor and recipient cats must always be blood typed before transfusion. Type-compatible blood should be administered – ie, type A blood is given to type A cats, type B blood to type B cats, and (if possible) type AB blood to type AB cats. For type AB cats, if type AB blood is not available, type A blood (or ideally just the type A RBCs following separation) may be given.

Blood typing (phenotyping)

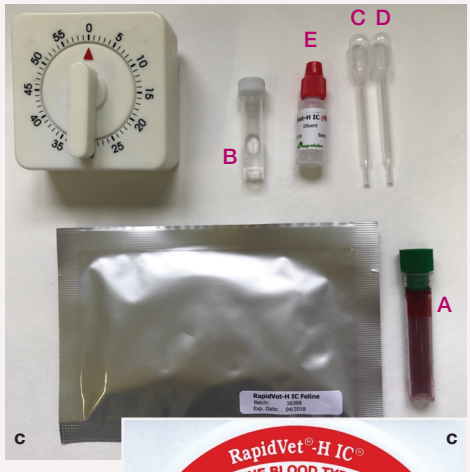
- Blood typing can be performed by submitting anticoagulated blood to a commercial laboratory or by using an in-clinic test kit.
- Different kits are available for in-clinic feline blood typing; examples useful for general practitioners include RapidVet-H cards (DMS Laboratories) based on agglutination (images [a] and [b] below)[17], RapidVet-H immunochromatographic (IC) tests (DMS Laboratories) (image [c]) and the QuickTest A+B (Alvedia) (images [d–h] on page 413),[17] also based on IC methodology. In addition, the Lab.Test A+B (Alvedia) is similar to the QuickTest A+B but can be run on multiple (up to 20) samples and requires a microplate, pipette and test tube to be provided by the user. A gel tube in-clinic blood typing kit is also available (RapidVet-H Gel; DMS Laboratories) that relies on agglutination; this method includes a step that requires use of a specific centrifuge.
- One study found that the in-clinic QuickTest A+B performed slightly better than the RapidVet-H card test, and may be more reliable in cats with autoagglutination,[18] but the RapidVet-H IC test also appears to be reliable.[19] A more recent publication, focusing on the Lab.Test A+B, found it to outperform the RapidVet-H cards;[20] the study also confirmed that the QuickTest A+B performed well on blood that had been stored in the fridge and at room temperature. A recent study confirmed that the Lab.Test A+B was very reliable, performing as well as flow cytometry in the blood type phenotyping of a sample of 49 cats (34 A, 13 B and two AB).[21]
- The QuickTest A+B is a migration IC methodology test strip cartridge (images [d–h] on page 413) that uses monoclonal antibodies (further details not given) to differentiate the blood antigens, whereas the RapidVet-H cards use a murine monoclonal antibody as the anti-A reagent and a lectin from *Triticum vulgaris* (wheat germ) as the anti-B reagent. These different reagents may explain why the RapidVet-H cards incorrectly describe blood type in some cases, with one study showing that the cards were found to sometimes mistype blood type AB cats as type B and occasionally blood type A cats as type AB.[20]

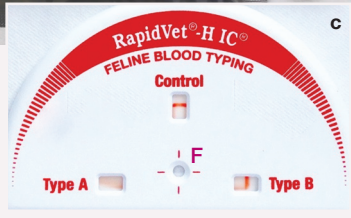
In-clinic blood typing test kits – RapidVet-H

(a) RapidVet-H cards (DMS Laboratories) are in-clinic kits that use a murine monoclonal antibody as the anti-A reagent in the type A well and a lectin from *Triticum vulgaris* as the anti-B reagent in the type B well. The top well is an autoagglutination saline screen that does not contain any anti-A or anti-B reagents – this control well is to ensure the cat's blood is not agglutinating spontaneously, as this would result in a false type AB result being read. Any autoagglutination in the control well would invalidate the test result. In this image the cat being tested is blood type A, as indicated by the agglutination in the type A well only



(b) To perform the RapidVet-H card blood typing test to obtain a result as in image [a], one drop of diluent (provided with the kit) and one drop of well-mixed feline EDTA patient whole blood is placed into each of the wells and mixed with a wooden stirrer (also provided with the kit), as shown, for 10 s per well. A new stirrer is used for each well. A further drop of diluent is then added to the type A well only and the card is lifted and gently rotated and rolled around to allow complete mixing before reading the results; results are read within 2 mins of having added the diluent and blood. A timer is useful for accurate timing





(c) RapidVet-H immunochromatographic (IC) tests (DMS Laboratories) are another in-clinic feline blood typing kit; this two-part image shows a test result for a type B cat. The test is based on sample migration along a membrane that contains bands loaded with monoclonal antibodies for antigens A (type A) and B (type B), and a control band (control). One drop of feline EDTA patient whole blood (A) is added to the tube containing the diluent (B) and is mixed well using one of the pipettes included in the kit (C). Using the other new pipette (D), three drops of the diluted blood and three drops of the included buffer (E) are placed into the central cartridge sample port (F). A test result is defined by the appearance of a clearly visible red vertical indicator line filling at least 25% of one, or both, of the type A or B viewing ports within 10 mins of starting the test, along with the appearance of a horizontal line in the control band; the latter validates the test result. A timer is useful for accurate timing

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different blood type phenotype. These alloantibodies are also responsible for neonatal isoerythrolysis,[15,16] a cause of neonatal death. The severity of a blood transfusion reaction depends on the quantity (ie, higher titres or concentrations are worse) and nature (eg, strongly agglutinating) of any alloantibodies present in the recipient or donor.

Non-AB feline blood groups

Evidence published in 2007[22] suggested that other (non-AB) blood group systems existed in cats because transfusion reactions have occurred in cats given AB-matched blood transfusions. The study from the USA reported the absence of a novel feline RBC antigen named Mik in three of 65 type A cats tested,

Blood typing (phenotyping)

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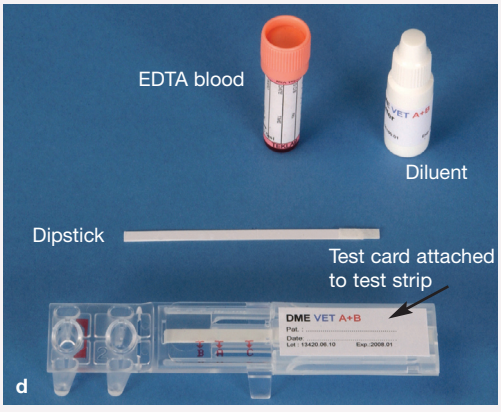
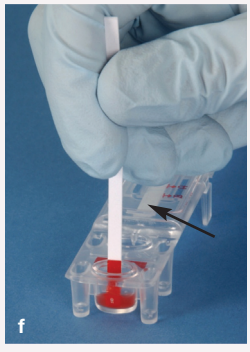
- An automated method for blood typing is available (QuickVet Feline Blood Typing Test), for use with the QuickVet Analyzer (Zoetis ApS). The QuickVet Diagnostic System consists of an analyser and single-use disposable test cartridges based on capillary-driven microfluidic technology.
- If a sample to be blood typed is from a cat with severe anaemia (packed cell volume [PCV] <14%), the RBCs can be concentrated by centrifugation of the blood (2–3 mins, remove some of the plasma supernatant and resuspend the remaining RBCs in the remaining plasma supernatant) before repeating the test; this can be useful if insufficient RBCs reach the top of the test strip due to the low number present in a very anaemic sample. In a similar way, if agglutination of the sample precludes movement of the RBCs along the strip, the RBCs can be washed in phosphate-buffered saline and the test repeated.
- One study found that some feline leukaemia virus (FeLV)-infected anaemic cats were mistyped using multiple blood typing methods.[18]
- Cats with less common blood types (type AB and type B) may be mistyped by commercially available in-clinic blood typing methods and any type AB and B results should ideally be confirmed at an external laboratory by a method that uses antibody testing or genetic screening. However, a 'back typing' technique for antibody screening can be used in-clinic to confirm a type B: EDTA blood from the suspected type B cat is centrifuged for 2 mins; 30 µl of plasma is removed and mixed with 15 µl of EDTA blood collected from a known type A cat on a glass microscope slide and observed for agglutination; if positive, this confirms the B blood type, as the plasma of the type B cat contains alloantibodies that agglutinate the type A RBCs.

In-clinic blood typing test kits – QuickTest A+B

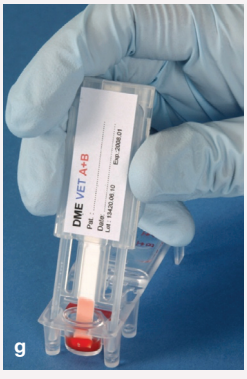


(d) The QuickTest A+B (Alvedia) uses monoclonal antibodies on a migration paper strip to determine blood type. The kit comes with all the equipment needed to test a sample of feline EDTA whole blood taken from the patient, but a timer is also useful to have available

(e) The diluent provided in the QuickTest A+B kit is added to one of the mixing wells

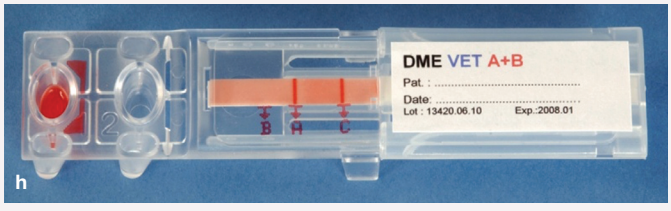


(f) The dipstick is placed into the EDTA blood sample and coated with the cat's EDTA blood before it is then transferred into the mixing well containing the diluent, as shown, and agitated for approximately 7 s. The dipstick is then discarded. The test card together with the test strip (arrow) is then removed from the plastic sheath separating them from the mixing wells



(g) The test card with attached test strip is then positioned upright into the mixing well that contains the mixed diluent and blood, as shown in this image. The diluent and blood mixture will then migrate (travel up) the test strip over approximately 2 mins

(h) Once migration is completed, the test card together with the test strip is removed from the mixing well and reinserted into the plastic sheath in the position they had at the start of the test, as shown below. This allows reading of the test alongside the A (type A), B (type B) and C (control) labels. In this image the cat is type A as there is a line against the A label, none against the B label, and the line against the C control label is present to validate the test result



Images [d–h] adapted, with permission, from Rudd[17]

in association with the presence of naturally occurring anti-Mik alloantibodies, which mediated a clinically significant transfusion reaction despite the blood donor and recipient cat being AB-matched.[22] However, one study in UK cats,[23] and another in German cats,[24] found no evidence of anti-Mik alloantibodies in the cats sampled, as no positive cross-matches between AB-matched blood samples were found in transfusion-naive cats.

Other studies have, however, documented the presence of positive cross-matches between

AB-matched blood samples,[21,25,26] suggesting the presence of non-AB blood group systems, although the clinical significance of these is not always clear and tests for Mik and other RBC antigens are not available commercially. In the most recent study,[27] type A cats were evaluated for naturally occurring non-AB alloantibodies by cross-matching and at least 7% of the cats had incompatible cross-matching, documenting the presence of naturally occurring alloantibodies. Five distinct RBC antigens were hypothesised to be present outside of the AB blood group system and one of these was thought to correspond to the previously described Mik antigen.[27]

When to cross-match

In emergency situations cross-matching may not be possible. However, it is strongly recommended that cross-matching is performed before a transfusion when the recipient has an unknown transfusion history or has had a previous transfusion reaction or has received a transfusion 2 or more days earlier. The 2-day timeline stipulated is because incompatibilities have been identified by major cross-match testing as early as 2 days after a first whole blood cross-match compatible transfusion.[24]

Cross-matching

Cross-matching can be performed in-clinic or at an external laboratory; the latter is ideal as the test is complex and takes time but obviously this results in a delay in obtaining results. In-clinic cross-matching kits are available. Based on all existing studies, the clinical effectiveness and need for cross-matching before a first transfusion remains controversial. However, given that transfusion-naive cats may have incompatible major cross-matches, cross-matching, as well as blood typing, is recommended by some before each transfusion where possible in cats,[27–29] although others have acknowledged that

How to perform in-clinic cross-matching

Cross-match methodology

- Obtain 1 ml of anticoagulated blood (EDTA tube) and 1 ml of non-anticoagulated blood (plain tube) from each of the donor and recipient. Label the tubes.
- Centrifuge (3000 rpm for 5 mins) and separate plasma and serum from RBCs in both tubes. Discard the plasma if not required for other diagnostic investigations. Store serum in a separate tube, and label.
- Wash EDTA RBCs – add 2–3 ml of normal saline solution to the RBCs, mix gently, centrifuge (3400 rpm for 1 min) and remove the supernatant saline. Repeat twice.
- After the third wash, decant the supernatant and resuspend the RBCs with saline to give a 4% RBC suspension (0.2 ml RBCs with 4.8 ml saline).
- Label four tubes and place the following into each:

Major cross-match	One drop of recipient serum and one drop of donor RBC suspension
Minor cross-match	One drop of donor serum and one drop of recipient RBC suspension
Recipient control	One drop of recipient serum and one drop of recipient RBC suspension
Donor control (optional)	One drop of donor serum and one drop of donor RBC suspension

- Incubate the tubes for 15 mins at 37°C
- Centrifuge the tubes for 15 s (3400 rpm)
- Read the tubes macroscopically and microscopically

Macroscopic cross-match reading

In a compatible reaction there should be no clumping, haemolysis or agglutination present; when the tubes are gently rolled and rotated, red cells should be able to float off freely from the centrifuged 'pellet' of RBCs. The supernatant should be free of haemolysis (Figure 1).

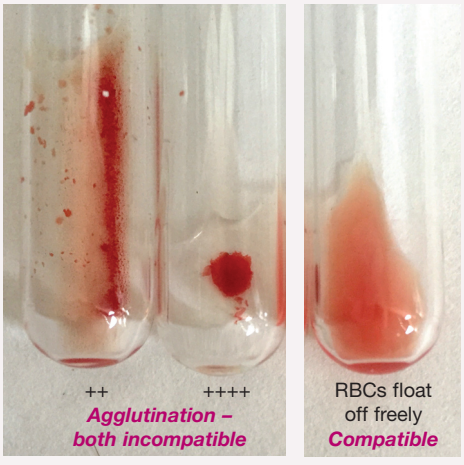


Figure 1 In-clinic cross-matching – macroscopic appearance. The tube on the right shows a compatible cross-match reaction where the red blood cells (RBCs) float off freely from the centrifuged 'pellet' of RBCs when the tube is rotated and rolled. The other two tubes show incompatible cross-match reactions with different grades of RBC agglutination (++ and ++++)

The reaction between the blood type alloantigens and any existing alloantibodies is observed during cross-matching of donor and recipient blood.

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the strength of evidence for this is weak.[30] A recent Australian study, surveying primarily general veterinary practitioners, reported that compatibility testing, including cross-matching, before feline blood transfusions was commonly performed; cross-matching alone by 26% of respondents, blood typing alone by 27.6%, and both by 34.1% of respondents.[31]

How to perform in-clinic cross-matching

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Microscopic cross-match reading

A drop of the RBC/serum mixture from the tubes is placed on a microscope slide, a cover slip is applied and the slide is viewed microscopically (within 1 min of placing the blood mixture on the slide). The RBCs should be visible as individual cells and not in clumps. Rouleaux formation, where RBCs stick together to resemble stacks of coins, can look macroscopically like agglutination but can be differentiated on microscopic examination (Figure 2). Rouleaux formation (Figure 2a) is not a clinical concern, while agglutination (Figure 2b) indicates an incompatible cross-match reaction.

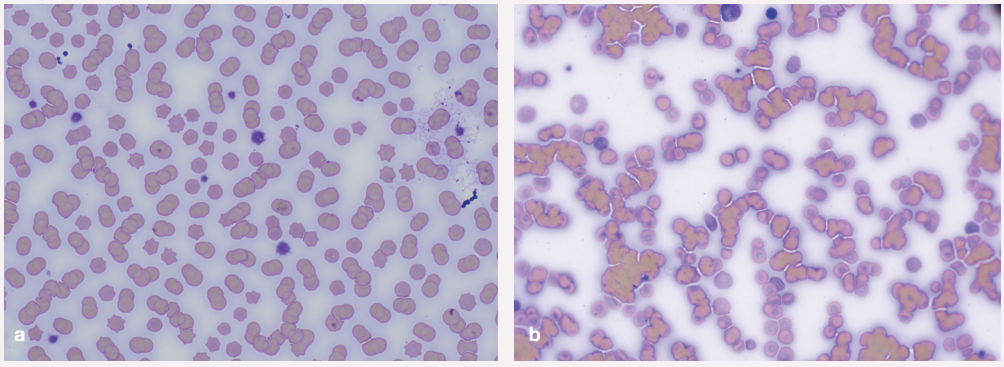


Figure 2 **In-clinic cross-matching – microscopic appearance. (a) Microscopic appearance of rouleaux, in which the RBCs resemble stacks of coins; this is not of clinical concern and does not indicate a cross-match incompatibility. (b) Microscopic appearance of agglutination showing a disorganised mass of RBCs in clumps, indicating an incompatible cross-match reaction.** *Images courtesy of Nic Ilchyshyn, Dick White Referrals, Six Mile Bottom, UK*

NB. Others have modified the above protocol to use plasma rather than serum (as both can be used for cross-matching[32]), along with a 3–5% suspension of RBCs in phosphate-buffered saline (rather than saline), and by performing just the recipient control test and not the donor control.[24] The study describing this modified method also reported that cross-matching could be carried out with as little as 250 µl (0.25 ml) of blood,[24] which is encouraging as minimising the amount of blood taken from anaemic cats is important.

Use of in-clinic cross-match kits

In-clinic cross-match kits are available such as the RapidVet-H Major and Minor Cross-match kits (DMS Laboratories), which use serum, and the QuickTest XM EmMaTest or Lab.Test XM (both Alvedia), which use plasma. A feline Gel Test (Alvedia), which uses plasma, is also available for cross-matching, but this requires the mandatory use of a specific centrifuge. With all such kits, instructions should be carefully followed. Nonetheless, studies have yielded variable results with different methods, and it is difficult to compare results.[27]

Emergency cross-matching

If cross-matching is required in an emergency, the following method can be used, which omits the washing of RBCs described above:

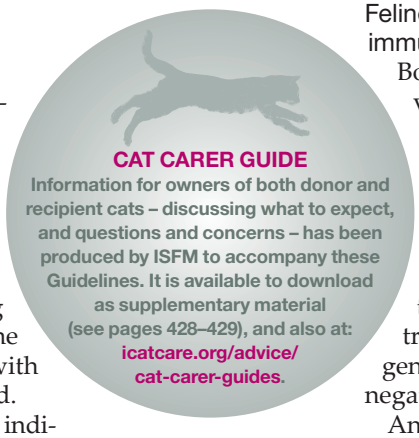
- EDTA-anticoagulated blood is collected from donor and recipient, and then centrifuged to separate plasma and RBCs
- *Major cross-match*: two drops of recipient plasma and one drop of donor RBCs are placed on a glass microscope slide and the slide is examined macroscopically and microscopically for the appearance of agglutination within 1 min, as described above. Agglutination must be differentiated microscopically from rouleaux formation, as described above for routine cross-matching
- *Minor cross-match*: one drop of recipient RBCs is mixed with two drops of donor plasma on a glass slide and examined as described above
- Controls should also be performed using recipient plasma and RBCs and, if possible, donor plasma and RBCs, and examined microscopically
- Note that drying out of blood on the slide can result in rouleaux formation but this takes >5 mins to occur

Selecting a donor

Infectious disease screening

Risks from transfusion include the transmission of infectious agents from donor to recipient, which can be largely avoided through donor selection and screening. Such a process must inevitably vary between countries/regions and practices, and will depend on locally endemic diseases, the practicalities of selecting donors that do not carry them and the cost/availability of screening compared with the risk of not having any available blood.

In addition to the considerations above, individual donor factors such as indoor/outdoor status, ectoparasite control and time of last testing will influence the likelihood of infectious agent presence. These factors will in turn determine which agents should be screened for, the most appropriate methodology and also the required frequency, which may be deemed to be annually, or at the time of every blood donation if there is a high risk of novel exposure or intermittent circulation of a pathogen.[33,34]



Core infectious agents to test donor cats for

Haemotropic mycoplasmas

The pathogenic epierythrocyte parasitic bacterium *Mycoplasma haemofelis* can be transmitted by blood products, although it appears to be inactivated during storage of whole blood for 1 week.[35] Blood smear evaluation is insensitive for diagnosis and also lacks specificity, and thus the diagnostic test of choice for screening blood donors is PCR. PCR testing for '*Candidatus* Mycoplasma haemominutum' (which may survive for a week in stored blood[35]) and '*Candidatus* Mycoplasma turicensis' can also be considered; however, as these agents are of lower pathogenicity,[36] donors may not be excluded if positive for these organisms if the donor pool is very limited. Ideally, however, cats should be negative for these agents, too.

Bartonella species

Numerous *Bartonella* species can be present in the blood of cats and have been associated with several clinical conditions.[37] *Bartonella henselae* has been shown to survive in stored blood.[38] Donors should ideally be serology and PCR negative for *Bartonella* species but seropositivity may be common in endemic areas and sensitive testing methods are not always readily available. Seropositive cats may have intermittent bacteraemia,[39] but can be considered for donation if PCR negative.

Feline leukaemia virus/feline immunodeficiency virus

Both FeLV and feline immunodeficiency virus (FIV) can be transmitted by blood transfusion and thus donor cats need to be negative for these agents.[40] Antigen tests for FeLV are commonly available, such as ELISA or IC in-clinic tests, but proviral DNA testing (by PCR) should be performed, if at all possible, as transmission of FeLV infection through transfusion of FeLV provirus positive, antigen negative blood (eg, PCR positive, ELISA negative) has been documented.[41]

Antibody tests for FIV are commonly available as ELISA or IC in-clinic tests, too, and cats should be negative for FIV antibody before being used as donors. Although certain FIV antibody tests may be able to differentiate true FIV infected cats from those cats that have been vaccinated for FIV (in countries where FIV vaccination is, or has been, available for use in cats), it is recommended that only FIV antibody negative cats are used as blood donors due to the potential for confusion in interpretation of test results.[42]

Additional agents to consider testing donor cats for

Anaplasma species

Anaplasma phagocytophilum can cause illness in cats, and can be transmitted by blood inoculation and exist as a persistent infection.[43,44] Donor cats with potential tick exposure (particularly *Ixodes ricinus*) from endemic areas should ideally be screened by serology and PCR, if available. Seropositive, PCR negative cats may be used in endemic regions if no other suitable donor can be identified. Infection with *Anaplasma platys* has been documented in cats,[43] and so cats living in areas endemic for *Rhipicephalus* species ticks should be screened for this agent by PCR.

Cytauxzoon felis, *Babesia felis*, *Ehrlichia canis*, *Leishmania infantum* and *Neorickettsia risticii*

These are all vector-borne agents,[43–49] and may be transmissible by blood products. Although pre-donation physical examination and blood smear examination should minimise transmission risk, the optimal standard would be for donor cats to be negative by PCR, if available, for these agents if living in endemic areas.

Other infectious agents

Screening for coronavirus, *Rickettsia felis* and *Toxoplasma gondii* is not recommended for donor cats. Transmission of these agents by blood products has not been documented.

Risks of transmission of infectious agents from donor to recipient can be largely avoided through careful donor selection and screening.

Donor characteristics

Donors should be healthy, and between 1 and 8 years old, with a lean body weight above 4.5 kg. They should be of calm temperament and easy to handle to reduce sedation requirements. All applicable vaccinations and parasite control should be current and donors should ideally live indoors without recent introduction of other cats to the household, to reduce their exposure to infections. No other recent medications should have been given and they should never have received a transfusion nor be currently pregnant. Cats that have previously had a litter may still be donors.

Annual health screening of potential blood donors, including haematology and serum biochemistry profiles, is recommended. In addition, a complete history and physical examination, as well as determination of packed cell volume (PCV) or haemoglobin concentration, should be completed before each blood collection.

Occult cardiomyopathy is excluded with echocardiography screening by some clinicians prior to allowing cats to join a donor programme, given that up to 30% of cats with cardiac disease will not have a murmur.[50] However, others would omit echocardiography and exclude cats with murmurs, gallop rhythms or arrythmias from donation, or perform quantitative NT-proBNP serum testing, which has been shown to reliably discriminate normal cats from those with occult cardiomyopathy.[51]

Ideal donor selection criteria

- Between 1 and 8 years of age
- Lean body weight above 4.5 kg
- Calm temperament
- Up to date with relevant vaccination, worming and ectoparasite treatments
- No current medications
- Ideally living indoors
- No history of having received a transfusion
- Annual haematology and serum biochemistry screening within reference intervals
- FeLV antigen and FIV antibody testing negative (can be done in-clinic) and FeLV provirus PCR negative
- Haemotropic mycoplasma and *Bartonella* species PCR negative
- Negative for vector-borne pathogens in endemic areas

Indications for blood transfusion

Due to restrictions on storage of animal blood, most cats in the UK and Europe in need of a blood transfusion will receive fresh whole blood (FWB), which contains all of the blood components: RBCs, platelets, coagulation factors and plasma proteins. However, in countries where blood storage is available, feline FWB donations are processed into packed red blood cells (pRBCs) and fresh-frozen plasma (FFP) components. The use of these blood components has many advantages including extending resources, allowing specific replacement therapy, and potentially reducing the number of transfusion reactions.

RBC products

RBC products, namely FWB and pRBCs, increase the oxygen-carrying capacity of the blood and thereby improve oxygen delivery to tissues. While FWB and pRBC transfusions can be used interchangeably in most anaemic cats, administration of pRBCs would be preferable to FWB for those, for example, with underlying cardiac disease to help avoid circulatory overload, as well as for those, for example, with anaemia due to haemolysis rather than blood loss.

When to consider an RBC transfusion

The decision to transfuse RBC products is based on several factors in addition to PCV, including the onset of anaemia (if acute in nature, there may be more of a need compared with chronic-onset anaemia), presence of ongoing RBC losses and, most importantly, the clinical signs of the patient. Tachycardia, bradycardia, bounding peripheral pulses, collapse, lethargy, panting and weakness are all signs that should prompt consideration of an RBC transfusion.

The decision to administer an RBC product transfusion is frequently based on measurement of the cat's PCV, haematocrit or haemoglobin concentration. However, a 'transfusion trigger' or threshold PCV below which an RBC transfusion is administered has not been clearly defined in human or veterinary medicine, and accompanying clinical signs are very important to consider in deciding if a transfusion is required. In two studies involving RBC transfusions in more than 265 cats, the pre-transfusion PCV was 15% (median value[25]) and 17% (mean value[26]), with a range of 5–40%. In some cats with peracute blood loss and hypovolaemia, RBC transfusions may be indicated even though their PCV is normal. These patients will predictably develop a low PCV following fluid resuscitation with asanguineous fluids.

Ineffective erythropoiesis and blood loss are the most common general causes of anaemia reported in cats receiving RBC transfusions, with haemolysis noted less frequently in approximately 5–25% of cats.[25,26,29] Underlying conditions frequently associated with development of non-regenerative anaemia in cats, and the potential need for an RBC transfusion, include chronic kidney disease, lymphoma, systemic inflammatory disease, infectious diseases, bone marrow disorders[52] and chronic unspecified diseases.[29] An often-overlooked factor contributing to development of anaemia in hospitalised critically ill cats is repeated phlebotomy for blood sampling, with 74% of non-anaemic cats in one intensive care unit population going on to develop anaemia during the hospitalisation period.[53] In this study, cats that required a pRBC transfusion had significantly more daily blood samples taken (median 3 blood samples, range 1–6) than cats that did not require a transfusion (median 2 blood samples, range 1–4).[53]

Plasma products

Plasma separated from RBCs within 8 h of blood collection is referred to as fresh plasma, but in countries where stored veterinary blood products are available, fresh plasma is more often frozen after preparation and stored (at –20° to –30°C) for up to 1 year; this type of plasma is referred to as fresh-frozen plasma (FFP). Fresh plasma and FFP contain haemostatic proteins (coagulation factors, von Willebrand factor, anticoagulant proteins and fibrinolysins), albumin and immunoglobulins.

The main indication for use of fresh plasma or FFP is bleeding due to inherited or acquired coagulopathies, but use of these products has also been reported in cats with hypotension, liver disease, neoplasia and sepsis.[54] Although the benefit of prophylactic administration of plasma to cats with a coagulopathy (but not showing clinical signs of bleeding) undergoing an invasive procedure is unclear, it was reported to be the main reason for FFP transfusions in cats in another study.[55] Anticoagulant rodenticide toxicity is uncommon in cats compared with dogs, but may occur after consumption of poisoned prey, and FFP as well as FWB may be included in the treatment protocol.[55–57]

Hereditary haemostatic disorders are diagnosed infrequently in cats. There are two case reports of type 3 von Willebrand disease (VWD)[58,59] and sporadic reports of haemophilia A and B[55,60,61] causing bleeding in cats. Plasma would be appropriate to provide replacement of von Willebrand factor or factor VIII or IX in cats with VMD, or haemophilia A or B, respectively, that are experiencing bleeding, though FWB would be an alternative if fresh plasma or FFP was not available or the cat was also anaemic.

The effect of plasma on colloid osmotic pressure is less than that of synthetic colloids; therefore, plasma is less effective for volume expansion.[62]

Platelet products

Owing to technical challenges associated with preparing platelet-rich plasma from a small volume feline FWB unit, cats in need of a platelet transfusion generally are administered FWB, although this will not provide adequate platelets to correct thrombocytopenia.

There are few indications for platelet transfusions in cats, but they include uncontrolled or life-threatening haemorrhage (eg, pulmonary haemorrhage) with thrombocytopenia or thrombopathia, and possibly massive transfusion (rare, but is when a high number of pRBCs have been given, which can cause a dilutional effect on the recipient's clotting factors and platelets). While platelet disorders are uncommon in cats, primary immune thrombocytopenia can lead to severe blood loss anaemia, which can be managed with FWB transfusions.[63] Cats with bleeding secondary to a thrombopathia typically require administration of functional platelets (for practical reasons in the form of FWB) to control bleeding.[64]

Xenotransfusion

Xenotransfusion is defined as the transfer of blood from one species to another. Successful administration of whole blood or pRBCs from dogs to cats has been documented and can be performed if absolutely necessary but only as a single, one-off transfusion.[65,66] In some circumstances, canine blood may be more readily available than feline blood, and also in larger volumes, leading to its occasional use.[31]

Potential indications for xenotransfusion include a previous transfusion reaction to feline blood products, insufficient time to blood type the recipient, unavailability of suitable feline blood products in sufficient quantities, or financial constraints. Xenotransfusion is mainly used for short-term stabilisation of an anaemic cat, allowing time for investigations or to obtain compatible feline blood, or time for endogenous erythropoiesis to correct the anaemia[65–68] with or without appropriate treatment. Typically, 25 ml of pRBCs or 30–50 ml of FWB is administered using the same administration rates (see later) as feline blood, with the minimum volume needed to stabilise the patient being provided.

Antibodies to donor canine RBCs are detected 4–7 days following transfusion of canine blood into cats,[67] resulting in destruction of donor RBCs and a late haemolytic reaction, and hence a shorter life span of the donor canine RBCs compared with the life span of appropriately typed feline RBCs (30 days[69]). Any subsequent repeat transfusion of canine blood to the cat would result in a severe transfusion reaction, anaphylaxis and likely death.[65] Reported short-term complications following xenotransfusion are similar to cat-to-cat transfusions (allotransfusions), with minor febrile non-haemolytic transfusion reactions seen in 12% of cases.[68] A severe acute anaphylactic transfusion reaction immediately upon administration of canine whole blood to a transfusion-naive cat has been observed by one of the Panel authors (RK). Delayed haemolysis, often manifesting as icterus, occurs in 64% of cats at a median of 2 days (range 1–6) after transfusion,[68] meaning the benefits of xenotransfusion are short-lived compared with allotransfusion.

The benefits of xenotransfusion are short-lived compared with allotransfusion.

Pre-xenotransfusion cross-matching results do not appear to predict the development of transfusion reactions.[67,68] In one study, the long-term outcome of cats given xenotransfusions appeared to be associated with their primary disease.[68] Those that recovered appeared to have no notable adverse effects that could be directly attributed to the xenotransfusion itself.

Autologous blood transfusion

Autologous blood transfusion (autotransfusion) is the administration of a patient's own blood as a transfusion. This can be considered in patients with haemothorax or haemoperitoneum. Cross-matching or blood typing is not required. Blood is collected in a sterile fashion using a 23 G butterfly needle and 10 or 20 ml syringes. Administration of the collected blood is otherwise similar to standard donor–recipient transfusions. There is no clear evidence regarding whether anticoagulant should be added to the transfusion. Blood in contact with the peritoneal surface is reported to become defibrinated within 1 h and anticoagulant administration may be unnecessary or lead to hypocalcaemia. The use of an 18 µm blood filter is strongly recommended to remove microaggregates from the transfusion.

A report of eight cats with haemoperitoneum receiving autologous transfusion did not identify any adverse reactions.[70]

Chemical restraint of the donor for blood transfusion

It is possible to perform blood collection in conscious cats with a skilled veterinary care team. Patients must be cooperative but, even still, blood donation may be a negative experience for donors. Movement during donation and signs of anxiety have been reported in conscious cats much more often than in sedated cats.[71] Additionally, stress produced by handling may affect the cellular and chemical composition of the blood (eg, hyperglycaemia).[72] Therefore, sedation or general anaesthesia is now commonly used for feline donors. The choice of a short-term (30 mins) protocol for chemical restraint will avoid an uncomfortable experience for the cat and failed, repeated interventions that could produce injuries to the veterinary care team. It will also influence owner satisfaction with the donor experience.[73]

Figure 3 Local anaesthetic cream can be applied over the cephalic and jugular veins of the blood donor, after clipping the hair, for desensitisation of the skin before chemical restraint. A light occluding bandage (cellophane is used here) protects the area where the cream has been applied. Approximately 20-40 mins later an intravenous catheter is placed in the cephalic vein for drug administration (low doses of ketamine and diazepam or midazolam, for example). The cat can be placed in its transport carrier or a cosy cat kennel in a quiet room or ward during these 20-40 mins. The jugular vein site will be used for blood withdrawal

Chemical restraint for feline blood donors is no different to any other anaesthetic procedure in the sense that preoperative examination and appropriate fasting (6 h) are mandatory. An anaesthetic plan, including monitoring and careful choice of dosage regimens, is required. The use of local anaesthetic creams (Figure 3) and pheromones may be part of the overall management of the patient to help reduce stress.

The intravenous route of administration is often preferred due to the rapid onset of action and the use of lower doses of anaesthetic agents when compared with the intramuscular and subcutaneous routes. Several studies have reported the feasibility of different drug combinations, as well as effects on major blood analytes, in cat donors (see Table 2). Overall, each protocol has its unique advantages and disadvantages. Ideally, the drug combination should have a short onset with adequate depth and duration of action, and include a smooth and rapid anaesthetic recovery for the donor, with minimal cardiorespiratory depression. The choice will be also dependent on drug availability and the familiarity of the veterinary care team with the protocol. Eye lubricant should be applied to all cats regularly (every 35–45 mins) to avoid eye ulcers and lesions. Ideally, the cat should resume its normal behaviour, and eat and drink, shortly after the end of sedation/anaesthesia.

Alpha-2-adrenergic receptor agonists (xylazine, medetomidine and dexmedetomidine) are to be avoided for several reasons (see Table 2). Propofol produces significant cardiorespiratory depression and may lead to the formation of Heinz bodies, so is also best avoided. Ketamine is often used as a component of drug protocols; however, it should not be administered alone since muscle jerks, hallucinogenic behaviour, hyperaesthesia and emergence delirium (growling, biting, scratching, lunging at the cage) have been observed. Sevoflurane has been used for feline blood donation since induction of, and recovery from, anaesthesia is rapid and predictable, but there are significant concerns regarding its use (see Table 2).

Monitoring of mucous membrane colour, temperature, pulse and respiratory rate of the donor cat should be performed throughout the sedation/anaesthetic procedure and blood collection. Pulse oximetry can be used as a non-invasive method to determine the percentage of arterial haemoglobin saturated with oxygen (SpO_2). The device can be placed over the plantar digit of a pelvic limb during collection. Hypothermia is prevented by positioning the cat over a circulating warm water blanket or other warming device (with appropriate safety measures). Blood donation implies controlled losses of up to 20% (40–60 ml) of a cat's blood volume over a short

A short-term protocol for chemical restraint will avoid an uncomfortable experience for the donor cat.

Table 2 Summary of different drug combinations that can be used in blood donors and their effect on major blood analytes

Drugs (reference[s])	Dose /dosage or inhalant concentration in common usage	Comments	Changes in blood analytes reported
Ketamine and diazepam[74]	10 mg ketamine + 0.5 mg diazepam per cat, both IV	Protocol for short-term venepuncture (5 mins). Short onset and duration of action with excellent chemical restraint but may not be enough to complete phlebotomy. Note diazepam should not be administered IM	Minimal decreases in plasma triglycerides and albumin, and minimal increases in activated partial thromboplastin and prothrombin times, likely without clinical relevance
Ketamine and midazolam[75–77]	4–6 mg/kg ketamine + 0.4 mg/kg midazolam, both IM or IV	Mixed in the same syringe for IM injection. Prolonged anaesthetic effects, with ataxia and recumbency for up to 4–6 h after phlebotomy. Alternative protocols include the addition of butorphanol (0.3 mg/kg) or buprenorphine (0.01 mg/kg) IM. Hyperthermia may occur with ketamine-based protocols	Decreases of around 24–25% in RBC count, Hb concentration and PCV after higher doses of ketamine (10 mg/kg) and midazolam (0.5 mg/kg) IV. Based on these PCV changes, some donors may be falsely diagnosed with anaemia
Dexmedetomidine and butorphanol[73,75,78]	0.01 mg/kg dexmedetomidine + 0.2 mg/kg butorphanol, both IM	Ease of administration with short onset of action and possibility of dexmedetomidine reversal with atipamezole (0.1 mg/kg IM) are benefits. Also good muscle relaxation. Adverse effects include emesis, bradycardia, increased systemic vascular resistance and decreases in cardiac output. Peripheral vasoconstriction poses an additional challenge with respect to venous catheterisation and blood collection; several donations were aborted due to this. Higher doses of dexmedetomidine might be required in some cats. Overall, best avoided due to above-mentioned adverse effects	Decreases in RBC count, Hb concentration and HCT value (ie, sequestration of erythrocytes by the spleen induced by reduced sympathetic activity)
Alfaxalone and butorphanol[73,79,80]	2 mg/kg alfaxalone + 0.2–0.4 mg/kg butorphanol, both IM	Minimal cardiorespiratory changes. Large volume of IM injection. Rapid recovery from anaesthesia (just over 30 mins). Additional sedation or gentle physical restraint might be required in some cats; further administration of alfaxalone (0.1 mg/kg IV) can be used but will prolong duration and recovery of anaesthesia. Twitching has been observed by one of the Panel authors (PS)	No changes in complete blood count or serum biochemical values in experimental cats after doses of 5 mg/kg and 15 mg/kg IV of alfaxalone
Tiletamine and zolazepam[81]	2.5 mg/kg of each agent, both IM	Short onset of action. Hypothermia can be observed. Increases in heart rate and blood pressure due to hypovolaemia and drug-induced sympathetic stimulation	RBC, WBC, platelet, neutrophil and monocyte counts, HCT value and Hb concentration decreased, and lymphocyte, eosinophil and basophil counts increased after blood collection (not statistically significant)
Sevoflurane[76]	Mask or 'box' induction with sevoflurane (4–5% for induction followed by 2–3% for maintenance using 2 l/min of oxygen)	Potentially stressful to the cat to be restrained for mask or box induction, plus risk of environmental exposure of the veterinary care team to the inhalant anaesthetic. Hence not recommended for collection of blood from donor cats. Higher prevalence of hypotension when compared with ketamine combinations	Not reported

RBC = red blood cell; HCT = haematocrit; Hb = haemoglobin; WBC = white blood cell; PCV = packed cell volume; IV = intravenous; IM = intramuscular

period of time. As hypotension (systolic blood pressure <80–90 mmHg, mean blood pressure <60–70 mmHg, diastolic blood pressure <40 mmHg) is commonly observed with both injectable and inhalant anaesthetic protocols,[76,82] blood pressure monitoring is recommended due to the potential for hypovolaemia and anaesthetic complications. Depending on the donor protocol, balanced crystalloid solutions may be provided intravenously or via the subcutaneous route immediately after donation. Arterial partial pressure of oxygen can decrease during chemical restraint and oxygenation via a tight facemask is recommended. Desaturation (SpO_2 <90%) indicates hypoxaemia and oxygen therapy must be administered, especially with protocols using a combination of opioid–dexmedetomidine–ketamine or alfaxalone.[83] Other measures may additionally be required including drug reversal and termination of the procedure.

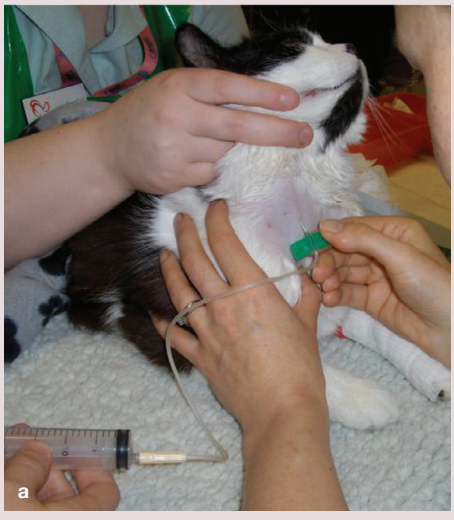
Feline blood collection: open system

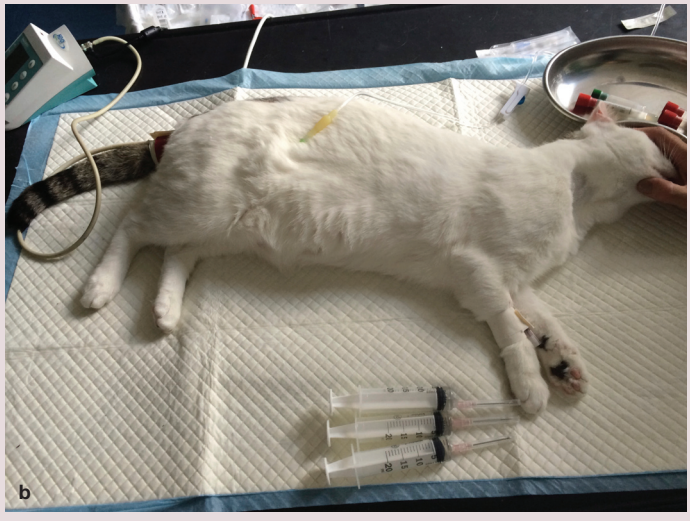
Equipment

Key:
A: Surgical spirit and B: swabs with chlorhexidine to clean the jugular vein site for blood withdrawal
C: A human standard blood collection bag from which the anticoagulant citrate–phosphate–dextrose (CPD) or citrate–phosphate–dextrose–adenine-1 (CPDA-1) will be taken aseptically into the syringes
D: Six 10 ml collection syringes (alternatively others use three 20 ml syringes or one 60 ml syringe, although the latter can produce too much negative pressure which may collapse the jugular vein during blood collection)
E: 15 21 G 5/8" needles to aspirate anticoagulant into each collection syringe and to use as caps for the collection syringes before and after blood collection
F: T-connector and three-way tap
G: Blood giving set with filter for administration of blood to the recipient cat (blood can alternatively be administered via a syringe driver with inline filter)
H: 150 ml plain blood collection bag into which the collected blood in the syringes can be transferred for administration to the recipient if needed
I: Artery forceps to seal the exit tube from the plain blood collection bag to prevent contents exiting via this route once the collection bag is filled with blood

Figure 4 **Equipment prepared for feline blood collection using an open collection system from a blood donor and administration to the recipient**

- A pre-donation blood sample can be collected from an intravenous catheter or peripheral vein for measurement of PCV or haemoglobin via a haemoglobin monitor. Blood collection is performed only if PCV or haemoglobin is in the reference interval.
- Syringes (multiple 10 or 20 ml, or one 60 ml) are pre-filled with an appropriate volume of anticoagulant (1 ml of ACD-A, CPD or CPDA-1 per 7 ml of blood to be collected).
- The donor is restrained in the position preferred by the phlebotomist; for example, a sitting position with head raised (especially if not sedated). If sedated, the cat can be placed in sternal recumbency with forelimbs over the edge of the table and the head raised, or in lateral or dorsal recumbency with the neck extended (Figure 5).





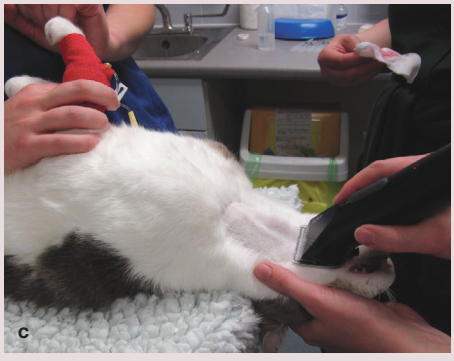


Figure 5 **Blood donor positioning for blood collection largely depends on the preference of the phlebotomist. (a) Here the sedated blood donor is in a sternal position. (b) This sedated donor has been placed in lateral recumbency with the neck extended. Blood pressure is being evaluated and monitored at the tail base, an intravenous catheter has been inserted in the cephalic vein and a whole blood sample has been collected (not shown) to check the donor's packed cell volume (or haemoglobin concentration). The cat lies on a warming blanket and has a needle inserted to provide subcutaneous fluids after the donation. (c) Here the blood donor is in dorsal recumbency; the jugular vein site is being clipped ready for blood collection, with the jugular vein clearly visible. The venepuncture site is then prepared using an aseptic technique.** *Image (a) courtesy of Sophie Adamantos; image (c) reproduced, with permission, from Rudd*[84]

Continued on page 422

Feline blood collection: open system

Continued from page 421

- The hair over the jugular vein is clipped (Figure 5c) and the venepuncture site is prepared using an aseptic technique.
- Pressure is applied at the thoracic inlet to raise the jugular vein, and a butterfly catheter (19 or 21 G) is inserted into the jugular vein.
- The phlebotomist keeps the butterfly needle within the jugular vein as still as possible while each syringe is filled in turn; meanwhile an assistant gently rocks the syringes to ensure mixing of blood and anticoagulant during collection. Sometimes occlusion of both jugular veins can accelerate blood collection if syringe filling flow has slowed down.
- After collection, the butterfly needle is removed from the jugular vein, and pressure is applied to the venepuncture site to prevent haematoma formation.
- If a blood clot is found in one syringe only, that syringe should be discarded if possible.

A more detailed step-by-step photographic guide to blood collection is available in Rudd.[84] A video showing open blood collection is available as supplementary material (see pages 428–429).

Production of pRBCs and plasma

While most cats in need of a transfusion in clinical practice receive FWB, the high erythrocyte sedimentation rate of feline blood allows for the separation of plasma and RBCs by simply placing blood-filled syringes upright for approximately 1 h at room temperature[85] (Figure 6a). Plasma can then be expressed into a transfer pack and frozen within 8 h of collection, if not needed immediately (Figure 6b). Packed RBCs can be administered directly from the syringe or expressed into a transfer pack containing 10 ml of an additive solution, such as saline–adenine–glucose–mannitol (SAGM), and stored in a refrigerator.[86] This is useful when feline blood components are not readily available from a commercial blood blank.

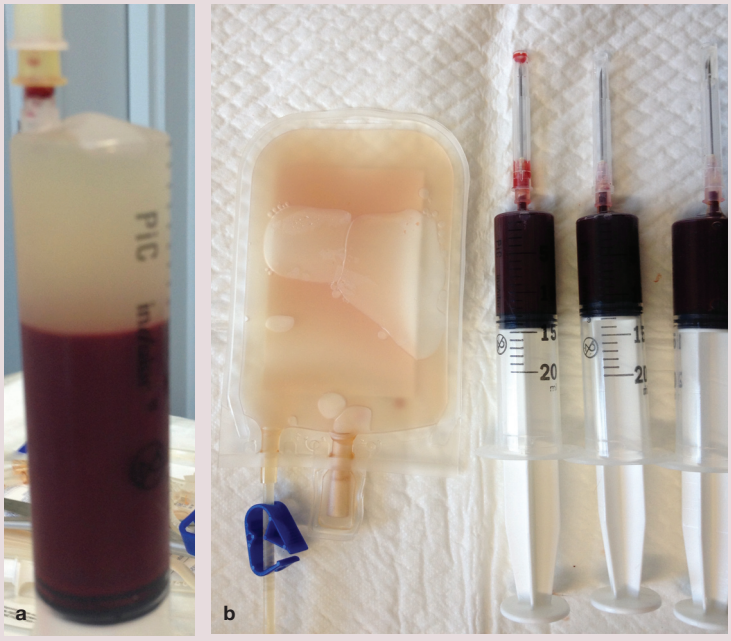


Figure 6 (a) Appearance of a syringe 1 h after blood collection, having been kept in an upright position at room temperature; the plasma has separated from the RBCs and is at the top of syringe. (b) The plasma from three 20 ml syringes, handled as in (a), has been transferred to a 50 ml human transfer bag. The RBCs remain in the syringes used for blood collection, ready to be transferred into another transfer bag to which 10 ml of an RBC preservative solution (such as saline–adenine–glucose–mannitol [SAGM]) is added to obtain a feline pRBC unit

Practical blood collection

The anticoagulant–preservative solutions most often used for collection of blood for transfusion purposes are ACD-A (anticoagulant citrate–dextrose solution), CPD (citrate–phosphate–dextrose) or CPDA-1 (citrate–phosphate–dextrose–adenine-1). The volume of anticoagulant used and the duration of time for which the blood product can be stored vary depending on the anticoagulant–preservative solution and the collection method. ACD-A, CPD and CPDA-1 typically are used in a ratio of 1 ml anticoagulant to 7 ml of blood. Sodium citrate (3.2% or 3.8%) alone (without RBC preservatives) may be used at a ratio of 1 ml anticoagulant to 9 ml of blood if the blood is to be administered within 24 h of collection. Heparin is not recommended as an anticoagulant for blood collected for transfusion.

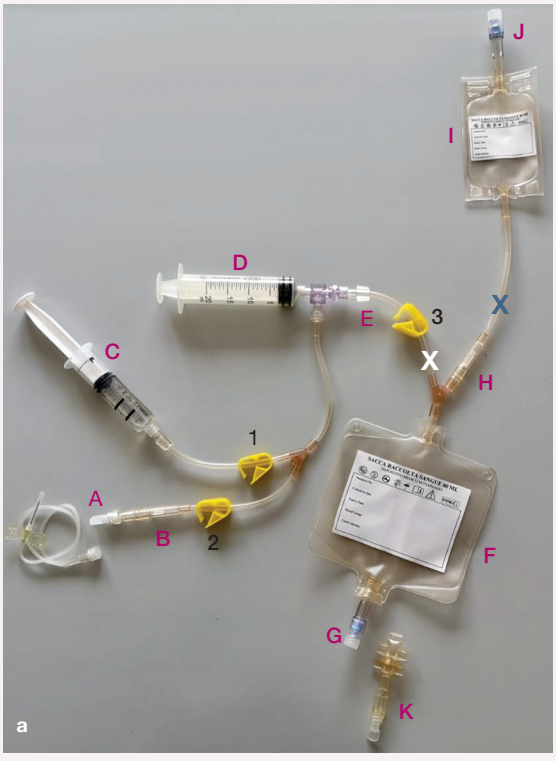
Blood collection systems are described as 'open' or 'closed'. A closed system is one in which the only exposure of the collection bag or its contents to air prior to administration is when the needle is uncapped to perform venepuncture during collection. An open system, as is frequently used in cats, is one in which there is one or more additional sites of potential bacterial contamination during blood collection or processing, with examples being the use of syringes or empty bags with added anticoagulant to collect blood (see box on pages 421–422). Blood products collected in an open system should ideally be administered within 4 h, or within 24 h if stored in a refrigerator (1–6°C).

Sedation not only reduces donor cat anxiety, but also potential movement and trauma to the jugular vein during donation.

A commercially available feline closed collection system (see box below) has been evaluated for storage of feline blood for 35 days. The investigators found that one of eight blood units showed bacterial growth (*Serratia marcescens*) on day 35 but not day zero,[87] highlighting the fact that bacterial contamination of a blood unit during collection is an issue

Feline blood collection: closed system

Equipment



Key:
A: Luer lock connection, with butterfly needle to the left
B: Break-valve
C: 10 ml syringe containing CPDA anticoagulant solution; two thick black permanent marker lines have been drawn on it to divide it into approximately three sections of just over 3 ml each
D: 20 ml collection syringe for aspiration of blood from the donor
E: Unidirectional valve
F: Primary whole blood 80 ml collection bag
G: Luer lock needle-free valve
H: Break-valve
I: Satellite 40 ml bag for decanting plasma later, if required, assuming a specialised centrifuge is available (unlikely in general practice)
J: Luer lock needle-free valve
K: Luer lock infusion adapter
1, 2, 3: Clamps
White and blue crosses show where tubes are sealed following collection – see text for further details

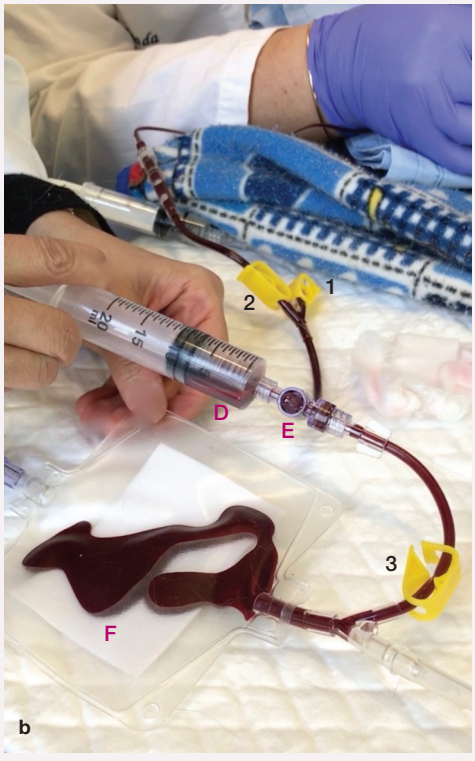


Figure 7 **Closed blood collection system (TEC 724 Kit; Futurlab) licensed for use in cats and in small animals. This is a medical device for veterinary use for collection of known volumes of blood from cats (in three steps of 20 ml each, for example). It is possible to use the device with donor cats of any size by connecting it to a butterfly needle of an appropriate gauge. (a) Equipment set-up before use. (b) Section of the equipment during collection, showing the 20 ml syringe (D) containing donor blood**

A TEC 724 blood collection kit for cats (Futurlab) can be used for closed blood collection, as described elsewhere.[87,88] A brief description of its use is provided below:

1 Close clamp 3, leave clamps 1 and 2 open (see Figure 7a).

2 Push the plunger of the 10 ml syringe 'C' up to the first thick black marker line to add around 3 ml of anticoagulant into the system. (On the first occasion, before the first withdrawal of blood from the donor, make sure the anticoagulant solution reaches the break-valve 'B' to prevent subsequent coagulation in the collection line. This means around 3 ml of anticoagulant will be in the closed collection system to go into the blood collection syringe 'D' alongside around 20 ml of blood aspirated from the donor; this maintains the approximate correct 1:7 ratio of anticoagulant to blood.)

3 Close clamp 1.

4 Remove the cap of the luer lock connection 'A' and connect it to the butterfly needle of the desired gauge to collect blood from the donor cat.

5 Obtain donor jugular vein access with the butterfly needle, ensuring it is correctly inserted and then held still.

6 Break the break-valve 'B' (this ensures that the donor blood is never in contact with the air, and that the system remains closed).

7 Draw the 20ml of blood into the 'D' syringe via aspiration – the blood comes into contact with, and will mix with, the anticoagulant previously placed in the system.

8 Once the 'D' syringe has been filled with blood mixed with anticoagulant, open clamp 3 and push the plunger of syringe 'D' so that the blood goes through the unidirectional valve 'E' into the primary bag 'F' (see Figure 7b).

9 Close clamp 3, open clamp 1 and then repeat steps 2, 3, 7 and 8.

10 Repeat step 9 until collection of blood is complete; the anticoagulant solution allows collection of up to 60 ml ± 10% of blood (primary bag capacity is 80 ml).

11 When the blood collection is complete, close clamp 2 and remove the butterfly needle from the donor, applying pressure to the jugular vein.

12 Separate the equipment at the point indicated by the white cross in Figure 7a by means of an electric or manual sealer. (A sealer is a tool used to close off the blood bag by occluding the tube using heat or metal; used mainly in blood banks, but available for purchase [metallic clamps can be used if not available].) This separates the blood-filled primary bag 'F' (and the satellite bag of plasma 'I') from the syringes and rest of the kit.

Continued on page 424

Feline blood collection: closed system

Continued from page 423

Infusion

To infuse the collected blood in 'F', connect the luer lock infusion adapter 'K' (provided with the kit) to the valve 'G' and remove the butterfly cap from the other end to connect with an infusion set with spike. If not given to the recipient immediately, the collected blood can be stored at 4–6°C. It is possible to take samples from the bag by connecting a luer lock syringe to the needle-free valve 'G'.

Production of pRBCs and plasma

Although unlikely to be carried out in general practice – as specialised blood bank centrifuges are usually only available in blood banking organisations – the closed collection kit shown on page 423 can also be used to divide the FWB collected into one pRBC unit and one plasma unit. This is done by spinning the primary and satellite bags in a blood bank centrifuge, then breaking the break-valve 'H' and transferring plasma to the bag 'I', which is then sealed at the position of the blue cross in Figure 7a. Samples from the plasma bag can be taken by connecting a luer lock syringe to the needle-free valve 'J'. The luer lock infusion adapter 'K' can be attached to the valve 'J' and connected to an infusion set with spike for administration.

regardless of whether an open or closed collection system is used. Another closed feline blood collection system was recently evaluated that permits blood collection by suction using a vacuum chamber; this accelerated the process without being detrimental to the blood donor or collected blood, therefore optimising collection.[89] In addition, the study directly compared this closed system with an open system for evidence of bacterial contamination of the units, and did not observe any difference between the two collection systems.[89] In a separate study, blood units and blood products collected using open systems were stored successfully for 35 days without microbial growth, although all blood banking was performed by experienced staff and blood was collected with appropriate aseptic collection methods, processing and careful storage to prevent contamination,[90] which may have contributed to this result.

The jugular vein is the recommended venepuncture site in cats because of its size and accessibility. Strict aseptic technique minimises the risk of bacterial contamination. In a retrospective observational study involving 115 feline blood donations (70 non-sedated and 45 sedated donors), evidence of cardiovascular or respiratory distress was noted in three non-sedated cats after donation; panting, tachypnoea and collapse were each observed in one cat, with all three donor cats determined to be normotensive within minutes of the untoward event and recovering fully.[71] Another large study of 3690 donations (81% performed under sedation) from 1792 feline donors revealed 1.14% suffered post-donation reactions, of which 0.22% were acute (weakness, pallor, tachypnoea and open-mouth breathing) and 0.92% were delayed (haematomas and skin rashes, negative behavioural reactions at home and gastrointestinal signs). All cats recovered fully.[92] Further study is required to assess the complication rate in sedated and non-sedated donors but, in most cats, sedation is preferred to reduce anxiety, and potential movement and trauma to the jugular vein, during donation. Evaluation of donor temperament should form part of the pre-donation assessment and examination.

After blood collection and during recovery from chemical restraint donors should continue to be monitored as discussed above (mucous membrane colour, temperature, pulse and respiratory rate, and systolic blood pressure if indicated) and optionally provided with subcutaneous or intravenous fluids. The cat may be discharged once vital parameters are in the normal range, it is able to ambulate normally and ideally after food is eaten.

Fluid therapy for feline blood donors

Provision of fluid therapy prior to, during or after collection of blood from a donor varies between centres and clinicians. According to one of the Panel authors (MBC), no detrimental effects are reported by large donor programmes when crystalloid fluids are not supplemented. Some authors provide 90 ml of lactated Ringer's solution subcutaneously prior to collection of the donation, and the same solution is administered intravenously at 10 ml/kg starting halfway through the donation.[91] Others supplement with a balanced crystalloid solution such as Hartmann's or lactated Ringer's solution, at 2–3 times the volume of blood collected, given immediately intravenously after the donation is completed.[84]

Blood products collected using an open system should ideally be administered within 4 h, or within 24 h if stored in a refrigerator.

Donation volume and interval

The amount of blood that may be collected safely from feline donors is approximately 20% of their blood volume every 4 weeks. Total blood volume in cats is approximately 50–60 ml/kg and, thus, a recommended volume limit is approximately 10–12 ml/kg for cats based on lean body weight.[82] For practical purposes, a routine feline blood collection is a total volume of approximately 40–60 ml, including anticoagulant. Most volunteer donor schemes using client-owned pets as donors extend the donation interval to every 8–12 weeks, and at this frequency supplementation with iron is not required unless a deficiency is detected.

Practical blood administration

Blood products are usually given intravenously via a peripheral vein, but occasionally via a central vein or via an intraosseous route in small cats and kittens. A dedicated intravenous line should be used.

Blood products should not be administered with intravenous fluids supplemented with calcium or glucose (eg, Hartmann's, lactated Ringer's). Calcium overwhelms the chelating ability of the citrate anticoagulant in stored blood and increases the risk of clot formation. Appropriate fluid choices would be 0.9% saline or Plasmalyte (Baxter International).

Blood products must be administered using an appropriate filter to reduce the numbers of red cell aggregates and microthrombi entering the recipient's circulation. Filters in standard fluid therapy administration sets are too small and blood will clot if administered through them. Use of a syringe and microaggregate filter system does not appear to damage transfused RBCs.[93] Use of a standard blood administration set that includes a filter by gravity flow is possible, but control of the administration rate is more difficult. Ideally, a syringe and syringe driver with an inline microaggregate filter system (eg, Hemo-Nate 18 µm filter; IMS) is best. In most centres, the filter is placed in the administration line as close to the patient as possible (Figure 8). Some Panel authors will filter the blood as it is aspirated from the bag into a syringe, prior to administration to the patient. Either is an appropriate method for removing microthrombi from the FWB or pRBCs.

Figure 8 An inline microaggregate filter (arrow) (Hemo-Nate 18 µm filter; IMS) has been placed in the administration line from the unit of blood, as close to the patient as possible. A video showing blood collected via an open system being attached to a haemofilter in preparation for transfusion to a recipient is available as supplementary material (see pages 428–429)

Infusion pumps have been theorised to damage RBCs during administration but their use allows precision around low rates of transfusion administration and they help to avoid inadvertent rapid delivery or volume overload. A recent study showed that the use of two linear peristaltic infusion pumps (NIKI V4 [Everest] and Infusomat FmS [B Braun]) did not result in more haemolysis than gravity alone.[94]

Transfusion volume and rate

The volume of blood product administered to a patient can be calculated with various formulae, with the following formula performing best in one study, although it was noted that formulae frequently fail to accurately predict recipient PCV post-transfusion.[95]

PCV % increase = volume of blood transfused (ml)/(2 × body weight [kg])

In practical terms, the administration volume is rounded to the nearest unit (40–60 ml of whole blood) unless the recipient is very small, in which case a half unit or 10 ml/kg may be administered.

The rate of administration of the transfusion is determined by the condition of the animal. Patients with severe clinical signs associated with anaemia (eg, weakness, tachycardia, tachypnoea, hyperdynamic or weak pulses, hypotension, dull mentation) may require blood products faster (ie, as a bolus or over 1–2 h). Alternatively, as cats with severe or chronic anaemia may have signs of left heart overload,[96] transfusions may need to be given over a longer period (eg, 4–6 h) to reduce the risk of transfusion-associated circulatory overload. However, recent work described a lack of transfusion-associated circulatory overload in anaemic cats and dogs receiving transfusions,[97] suggesting that such an adjustment may not be required routinely; it nonetheless remains a risk in patients with underlying cardiac disease, for example, and so close monitoring is always indicated. If blood products are kept at room temperature for more than 4 h there is a greater risk of bacterial contamination, which should also be considered when calculating administration rates.

Rate of transfusion administration

In patients not requiring rapid volume replacement, transfused blood should be administered at 0.5 ml/kg/h for the first 15 mins, with the patient monitored constantly for signs of a transfusion reaction (see later) such as vocalisation, tachycardia, hypersalivation, vomiting, diarrhoea, facial swelling/urticaria, piloerection or tachypnoea/respiratory distress. After this time, the rate may be increased to 1 ml/kg/h for 15 mins. If there is still no evidence of a transfusion reaction, the administration rate is increased so that the total volume of the transfusion is administered within a 4-h period, although some institute a period of 20 mins at 2 ml/kg/h before increasing the rate further. More rapid infusion after the initial period may be needed in some cases.

Figure 9 **(a) Monitoring of the recipient is performed frequently (every 5 mins) during the first 30–60 mins of a transfusion, as this is the most common time for a transfusion reaction to develop. (b) Later in the transfusion, monitoring frequency can be reduced based on the cat's response and vital parameter data trends**

Monitoring the recipient

Patients must be monitored very closely whenever receiving a blood transfusion, particularly within the first 30 mins of administration as this is the most common time for a severe transfusion reaction to develop. A baseline check of vital signs is performed before commencing the transfusion, including temperature, heart rate, pulse quality, blood pressure, mucous membrane colour, respiratory rate/effort, oxygen saturation and patient mentation.

These parameters are checked very frequently (initially every 5 mins) for the first 30–60 mins (Figure 9). Depending on the clinical status of the patient, a multiparameter machine may be used to allow continuous monitoring of heart rate, electrocardiogram, SpO_2, blood pressure and temperature throughout the transfusion. Assessment of vital parameter data trends (eg, gradual increase in heart rate, respiratory rate, temperature) is key to early identification of a transfusion reaction, and ensuring detailed records are kept throughout the transfusion is extremely important. An example blood product administration sheet used for monitoring cats to help allow for early detection of any problems is shown in the box below and available as supplementary material (see pages 428–429).

Transfusion reactions

Despite appropriate screening, transfusion reactions in cats remain unpredictable and can vary in severity. As described in Table 4, they can be defined as acute, acute-to-delayed or delayed. The most common transfusion reactions seen in cats include febrile non-haemolytic transfusion reactions, allergic reactions and transfusion associated circulatory overload. Transfusion reactions may cause immune-mediated haemolysis, which can result in jaundice, pigmenturia and/or pyrexia, mainly due to anti-blood type reactions. Transfusion reactions can also cause non-

Blood product administration sheet

Date .....

Weight ..... kg Vet .....

Blood type .....

Donor reference .....

Cross-matched? Y □ N □

Patient Sticker

Blood product *(likely whole blood)* ..... Unit size ..... ml

Dose estimation: ≈1% increase in PCV is seen for every 2 ml/kg of whole blood

Time	Rate	Volume given (ml)	Actual Rate Given	Monitoring – see below
Start	**0.5 ml/kg/h** for 1st 15 mins	Volume =	.....ml/h	T, P, R, BP every 5 mins for 30 mins & then every 15–30 mins and at end; or more frequently if any concerns
.....	**1.0 ml/kg/h** for next 15 mins*	Volume =	.....ml/h	
Finish	As prescribed – *but should not really exceed 10 ml/kg/h*	**Remainder of unit given so that transfusion completed within 4-h period.** Volume =	.....ml/h	

*some institute a 20 min period at 2 ml/kg/h before increasing the rate further

Example check intervals	Time	T (°C)	Pulse rate & quality	MMemb colour & CRT	RR & pattern	BP (mmHg)	PCV %	Comments
Start								
5 mins								
10 mins								
15 mins								
20 mins								
25 mins								
30 mins								
45 mins								
1 hr								
Optional 30 mins – add times as needed								
End – ideally within 4 h								

Total volume given (ml) _____

Any transfusion reactions? _____

Please record any notes and further checks on the patient's sheet.

Signs of a transfusion reaction include pyrexia, restlessness, vomiting, salivation, change in RR and/or pattern (dyspnoea), change in HR and/or rhythm, change in BP, weak pulses, vocalisation, diarrhoea, urticaria.

If any reaction is seen, the **transfusion should be stopped immediately**, and the **vet contacted**. The volume infused, and rate of infusion is recorded (do not discard the blood, line or fluids). Other considerations may be required under vet guidance:

- Start cardiopulmonary resuscitation (CPR) if necessary
- Examine the unit for haemolysis by spinning a microhaematocrit tube containing a sample of the donor blood and look for haemoglobinaemia
- Examine the recipient for haemolysis by spinning a microhaematocrit tube of blood from the recipient and look for haemoglobinaemia
- Consider starting IVF therapy (eg, crystalloid bolus at 10 ml/kg) – this may be required to avoid renal damage if severe intravascular haemolysis or if signs of shock are present (hypotension, pallor, tachycardia/bradycardia)
- Consider treatment with adrenaline (10–20 µg/kg of a 1:10,000 solution [100 µg/0.1 mg] per ml IV or IM) and antihistamines (eg, diphenhydramine 1 mg/kg IV or IM).
- If volume overload has resulted in pulmonary oedema, diuretic treatment and oxygen support may be required – chest imaging and/or echocardiography may be indicated
- Culture (or, eg, PCR) of a sample of the donor unit may be required if infection or contamination is suspected, but bacterial contamination is unlikely in fresh well-handled blood
- Antipyretics (eg, meloxicam) may be required in some cases (renal function must be ok)

Key: **CRT = capillary refill time; IVF = intravenous fluid; T = temperature; P = pulse rate; RR = respiratory rate; BP = blood pressure; MMemb = mucous membrane; PCV = packed cell volume**

This example blood product administration sheet is available as supplementary material (see pages 428–429) for practices to adapt for their own use

Patients must be monitored very closely when receiving a blood transfusion, particularly within the first 30 mins.

Table 4 Association of Veterinary Hematology and Transfusion Medicine (AVHTM) Consensus Working Group definitions of transfusion reactions

Transfusion reaction	Definition
Acute transfusion reactions	
Acute haemolytic transfusion reaction (AHTR)	Acute, non-infectious, immunological or non-immunological reaction that occurs secondarily to accelerated destruction of transfused or recipient red blood cells (RBCs) and is characterised by acute haemolysis. AHTRs occur during or within 24 h of blood product administration. Causes of AHTRs can be divided into blood type incompatibilities and other causes of damage to transfused blood cells. Blood type incompatibilities are immunological acute haemolytic reactions (type II hypersensitivity reactions) due to major or minor incompatibilities between donor and recipient RBCs. A classic example would be in the case of a type A unit of blood given to a type B cat. Non-immunological causes of AHTRs may include thermal, osmotic, mechanical or chemical factors that damage transfused blood cells
Allergic reaction	Acute immunological reaction that is secondary to a type I hypersensitivity response to an antigen within a blood product. This reaction occurs during or within 4 h of transfusion. It is characterised by clinical signs varying from transient and self-limiting to life-threatening anaphylaxis. Feline type I hypersensitivity reactions are typically respiratory (due to upper respiratory tract oedema, bronchoconstriction and excessive mucus production), although gastrointestinal signs and severe pruritus can also occur
Febrile non-haemolytic transfusion reaction (FNHTR)	Acute non-immunological or immunological reaction characterised by a temperature >39°C (102.5°F) *and* an increase in temperature of >1°C (1.8°F) from the pre-transfusion body temperature, during or within 4 h of a transfusion, where external warming, underlying patient infection, AHTR, TRALI (see below) and TTI (see below) have been ruled out
Transfusion associated circulatory overload (TACO)	Acute, non-immunological reaction that is secondary to an increase in blood volume mediated by blood transfusion, characterised by acute respiratory distress and hydrostatic pulmonary oedema. This reaction occurs during or within 6 h of transfusion. It is associated with clinical, echocardiographic, radiographic or laboratory evidence of left atrial hypertension or volume overload. These patients typically have a positive response to diuretic therapy
Transfusion associated lung injury (TRALI)	Acute, immunological reaction that is secondary to antigen–antibody interactions in the lungs. TRALI is characterised by acute hypoxaemia with evidence of non-cardiogenic pulmonary oedema on thoracic radiographs, during or within 6 h of allogenic blood transfusion. Patients diagnosed with TRALI have no prior lung injury, no evidence of left atrial hypertension and no temporal relationship to an alternative risk factor for acute respiratory distress syndrome (ARDS)
Transfusion associated dyspnoea (TAD)	Acute transfusion reaction characterised by the development of acute respiratory distress during or within 24 h of the end of a transfusion where TACO, TRALI, allergic reaction and underlying pulmonary disease have been ruled out
Hypotensive transfusion reaction	Acute, non-immunological reaction that is secondary to the infusion of stimulators of vasodilation and hypotension. It is characterised by the rapid onset of significant hypotension during or shortly after the completion of a transfusion, in the absence of other causes of hypotension, and improvement with cessation of the infusion. There is usually a decrease in systolic blood pressure of at least 30 mmHg from baseline
Citrate toxicity	Acute, non-immunological reaction that is secondary to the transfusion of a large volume of blood with citrate as the anticoagulant, and is characterised by a significant systemic hypocalcaemia within hours of initiating the transfusion
Hyperammonaemia	Acute, non-immunological reaction that is secondary to hyperammonaemia and characterised by signs of development of encephalopathy (neurological signs such as ataxia, head pressing, circling, seizures and vomiting), during or immediately after (minutes to a few hours) blood transfusion of stored blood or stored blood components. It is a potentially life-threatening reaction in patients with liver disease (liver failure, portosystemic shunt) or in premature neonates with an immature functioning liver, which are unable to metabolise and excrete ammonia properly
Acute-to-delayed transfusion reactions	
Transfusion transmitted infection (TTI)	Acute or delayed, non-immunological reaction secondary to the transfusion of pathogen-contaminated blood or blood components. TTI can occur hours to years after the transfusion due to the presence of the infectious agent in the blood/blood component unit collected from an infected donor, or from pathogen contamination of blood/blood component units during processing, storage or transfusion. Clinical signs are highly dependent on the pathogen transmitted and its pathogenicity for cats, and the clinical status of the recipient
Transfusion-associated graft vs host disease (TAGVHD)	Acute to delayed, immunological reaction that is secondary to donor lymphocytes engrafting on and eventually attacking host tissue. TAGVHD occurs 48 h to 6 weeks following transfusion and has a high mortality rate in human patients (>90%). The reaction is characterised by a skin rash, diarrhoea, fever, hepatic dysfunction and bone marrow hypoplasia. Liver and skin histopathology have a characteristic appearance. In humans, it is most common in immunocompromised individuals or when special circumstances cause transient immunosuppression
Delayed transfusion reactions	
Delayed haemolytic transfusion reaction (DHTR)	Delayed, non-infectious, immunological or non-immunological reaction that occurs secondarily to lysis or accelerated clearance of transfused RBCs. Delayed haemolytic transfusion reactions occur 24 h to 28 days after blood product administration. Immunological DHTRs are typically caused by a secondary immune response to the donor's RBCs. Non-immunological DHTRs occur due to thermal, osmotic, mechanical or chemical factors that damage transfused blood cells, causing delayed haemolysis
Delayed serological transfusion reaction (DSTR)	Delayed, immunological reaction that is secondary to the development of new, clinically significant antibodies against the transfused product without evidence of haemolysis. DSTRs occur 24 h to 28 days after a transfusion[24]
Post-transfusion purpura (PTP)	Delayed, immunological reaction that is secondary to alloimmunisation against platelet antigens. PTP is characterised by thrombocytopenia arising 5–12 days following transfusion of any platelet-containing blood product

Reproduced with permission from the AVHTM[98]

Figure 10 This cat demonstrates facial swelling, which can occur as a transfusion reaction. However, more common reactions include vocalisation, an increase in body temperature, vomiting and salivation

haemolytic sequelae, such as transient increases in body temperature, facial pruritis, facial swelling (Figure 10), vomiting and salivation. Increased vocalisation or agitation can often be a preceding sign to a non-haemolytic reaction.

In a study of 126 cats receiving blood transfusions, non-haemolytic reactions (7.9%) were more common than haemolytic reactions (0.8%).[99] In another study of 91 cats, a transfusion reaction was noted in only 1.2% of the cats.[57]

The risk of a transfusion reaction increases with subsequent transfusions (typically from 2 days after an initial transfusion).[24] However, in 27 cats that received multiple blood transfusions, transfusion reactions remained uncommon.[100] Appropriate record-keeping is nonetheless essential so that all treating veterinarians are aware that the patient has received a blood transfusion.

Should the patient develop mild signs of a transfusion reaction (eg, mild, 1–2°C increase in temperature or one episode of vomiting) then the transfusion rate should be reduced. If marked clinical signs develop the transfusion should be stopped and blood replaced with a crystalloid solution (see box below). Monitoring of the patient (temperature, pulse rate, mucous membrane colour and systolic blood pressure) should be continued for evidence of shock. Serum and urine should be assessed for haemolysis and haemoglobinuria with sample centrifugation to look for evidence of haemolysis of the transfused red cells (eg, red discolouration of serum or urine).

Cats may develop signs of volume overload following a transfusion. This is of particular concern in patients with cardiac disease, normovolaemic to hypervolaemic anaemic patients (eg, immune-mediated haemolytic anaemia), and chronically or severely anaemic patients, although, as mentioned above, transfusion-associated volume overload in chronic anaemia may be less of a clinical concern.[95] If patients become tachypnoeic following a transfusion, or develop a serous nasal discharge or conjunctival oedema, thoracic radiography or thoracic ultrasound should be performed to evaluate for pleural effusion, pulmonary oedema and to measure a left atrial:aorta ratio. If pleural effusion is present, thoracocentesis is indicated. If pulmonary oedema is present, furosemide 1–2 mg/kg IV is given every 2 h as required (based on respiratory auscultation, respiratory rate and response), and oxygen therapy should also be instigated.

Supplementary material

The following files are available online:

- Video showing blood collection from a donor cat under sedation using an open collection system.
- Video showing blood collected via an open system being attached to a haemofilter in preparation for transfusion to a recipient.

ISFM welcome endorsement of these Guidelines by the American Association of Feline Practitioners (AAFP).

Severe transfusion reactions

In the event of a severe transfusion reaction, the transfusion should be discontinued, and the patient assessed. If there are signs of shock (hypotension, pallor, tachycardia/bradycardia) a crystalloid fluid bolus (10 ml/kg) and adrenaline (10–20 µg/kg of a 1:10,000 solution [100 µg/0.1 mg] per ml IV or IM) should be administered and can be followed by a continuous rate infusion of adrenaline. Antihistamines (eg, diphenhydramine 1 mg/kg IV or IM) and corticosteroids (eg, hydrocortisone 2–4 mg/kg IV or IM or dexamethasone 0.05–0.1 mg/kg IM or IV) may also be considered, although evidence for use of corticosteroids in acute transfusion reactions is limited and patient contraindications and potential adverse effects should be taken into account. The donor blood sample/unit should be assessed by checking a PCV for evidence of haemolysis and potentially submitting a sample for bacterial culture.

SUMMARY POINTS

- Feline blood donation and transfusion can be performed safely and effectively in veterinary practice, but the decision to undertake these procedures must be made carefully.
- Donor and recipient cats should be blood typed, and ideally cross-matched if possible, prior to transfusion to avoid severe transfusion reactions.
- The decision to administer a transfusion is based on the potential recipient's clinical condition and cause of anaemia, rather than PCV alone.
- Donors should be assessed for health, temperament and infectious agents and, in most cases, sedated appropriately for blood collection.
- Blood can be collected using an open or closed system and recipients should be monitored for signs of a transfusion reaction.
- If compatible feline RBCs are not available, xenotransfusion may be given only once, in certain situations, allowing for short-term stabilisation of the recipient, but destruction of donated RBCs occurs after a short time.

- Blood product administration sheet.
- Cat Carer Guide: 'Tranfusion of blood and blood products in cats: information for owners'.

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This work did not involve the use of animals and, therefore, ethical approval was not specifically required for publication in *JFMS*.

Informed consent

This work did not involve the use of animals (including cadavers) and, therefore, informed consent was not required. For any animals or people individually identifiable within this publication, informed consent (verbal or written) for their use in the publication was obtained from the people involved.

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Appendix: Ethical considerations

There are important considerations around blood collection and transfusion, outside of the clinical procedure itself. Foremost, there is a need to balance the risk/benefit by carefully looking at both the donor and recipient in each case. Blood is a very precious resource harvested for the benefit of one cat, with no benefit for the donor. In practical terms, blood transfusions are not without risk to the donor, so there are many considerations and justifications needed prior to blood collection and blood product administration. Owners of donor cats must be well informed of the process and risks; for unowned cats, those responsible for their wellbeing must come to reasonable decisions for each individual.

Legal implications

The laws around blood collection and transfusion will vary internationally and readers are advised to familiarise themselves with local laws and also professional body guidelines in their region.

Recipient suitability

Recipient cats may need the products to improve their health, but blood typing and, ideally, cross-matching are vital to ensure the treatment is not actually detrimental. Similarly, close monitoring of cats receiving transfusions and prompt management of a transfusion reaction are important. Clinicians are expected to consider adverse effects of medications, and blood products are no different. Risk of reaction and expected longevity of the transfusion should be examined.

Recipient prognosis

Blood/blood products are precious resources. The clinician, therefore, has a responsibility to use the blood carefully, and not on cases with a very poor prognosis that are unlikely to survive or are likely to be imminently euthanased. Additionally, transfusion of blood products carries risks to the recipient, and so should not be undertaken without evidence of a clear benefit to the patient. In this situation alternative supportive medications should be considered while prognosis is examined and discussed.

Source of donor cat: in-clinic donors

In many areas of the world, donors are cats owned by clinic staff, the recipient cat owner's other cats or cats volunteered after public appeals. Unowned cats may also be used as donors in some areas. The clinician has a duty of care to ensure the health and wellbeing of both the donor and recipient cat in this situation. The includes ensuring blood collection will not have a negative clinical impact, but also that stress involved in the process does not have a negative welfare impact. The temperament of donors should be assessed by experienced staff, and cats suffering stress and anxiety in the clinic excluded as donors. All clinics (accredited ISFM Cat Friendly Clinics included) should have a process for minimising distress to donor cats and optimising their health. Additionally, clinicians have a duty of care to the donor cat's owner: they need to be well informed of the process and risks, courtesy of excellent communication (both verbal and written), so that they can truly provide informed consent. A Cat Carer Guide providing information for owners is available alongside these Guidelines as supplementary material and at icatcare.org/advice/cat-carer-guides.

Is 'donor' the correct term?

'Donor' may be the incorrect word to use in this context, as it implies consent or a 'gift' that the cats are unable to decide to give themselves. 'Harvesting' is a less comfortable term for blood collection but it may be more accurate. The donor is put at risk, with sedation (in most cases), venepuncture and removal of blood. This is a relatively unique situation where a veterinary intervention has no benefit for the cat, and therefore requires robust ethical consideration and justification.

Source of donor cat: blood banking and commercial supply

During the past few years there has been an increase in 'blood banking' and international transport of blood products. Cat blood and blood products can now be ordered with the click of a mouse. This has the potential to divorce the clinician from the process of blood collection but should not absolve them of an ethical responsibility to the donor cats. While in this situation the clinician's priority is the recipient cat under their care, knowledge of how the cats are sourced for blood banks (eg, owned or unowned cats) and an understanding of the level of care they are given when blood is collected, plus examination of adverse effect recording and reporting, is advised.

The 3 'Rs'

When seeking ethics approval for a study using live animals, researchers must apply what are called the '3Rs' (reduction, refinement, replacement). As applied to feline blood transfusions this would involve: reduction by collecting blood only when needed, ensuring no wastage or inappropriate use of blood products; refinement of the collection procedure to ensure wellbeing of the donor cat is prioritised; and replacement through use of a synthetic blood product, although none are currently available.

Staff experience

Blood collection and administration should not be approached without training. A knowledge of blood type and compatibility is important, as is practical training on, for example, efficient venepuncture to avoid trauma to the vessels. Staff should be able to recognise signs of a transfusion reaction and respond appropriately. Additionally, understanding and recognition of the causes and manifestations of stress is vital to avoid any compromise in donor and recipient welfare.

In summary, when planning a feline blood or blood product transfusion there are multiple considerations, both clinical and non-clinical, that must be taken into account by the attending clinician. While potentially lifesaving, the procedure can have a negative effect on the donor and the recipient if performed incorrectly. It is the clinician's responsibility to care appropriately for both parties, with health and wellbeing prioritised equally.