ACVIM Consensus Statement

Consensus Statements of the American College of Veterinary Internal Medicine (ACVIM) provide veterinarians with guidelines regarding the pathophysiology, diagnosis, or treatment of animal diseases. The foundation of the Consensus Statement is evidence-based medicine, but if such evidence is conflicting or lacking, the panel provides interpretive recommendations on the basis of their collective expertise. The Consensus Statement is intended to be a guide for veterinarians, but it is not a statement of standard of care or a substitute for clinical judgment. Topics of statements and panel members to draft the statements are selected by the Board of Regents with input from the general membership. A draft prepared and input from Diplomates is solicited at the Forum and via the ACVIM Web site and incorporated in a final version. This Consensus Statement was approved by the Board of Regents of the ACVIM before publication.

Canine and Feline Blood Donor Screening for Infectious Disease

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A combined meeting of the Infectious Disease Study Group of the American College of Veterinary Medicine (ACVIM) and the Association of Veterinary Hematology and Transfusion Medicine (AVHTM) was held at the 20th Annual ACVIM Forum in Dallas, TX, to discuss controversies in the screening of potential blood donor dogs and cats for infectious disease in North America. Results were presented at the 21st Annual ACVIM Forum in Charlotte, NC. Consensus was difficult to achieve on some issues, and the statements presented below reflect general uniformity of opinion.

Introduction and Statement of Problem

A blood transfusion generally is a life-saving measure, but absolute safety can never be guaranteed. In addition to immune-mediated reactions caused by infusion of allogeneic cells or proteins, bloodborne infectious organisms can be transmitted by transfusion, potentially causing disease in the transfused recipient. In an effort to reduce the potential for and actual incidence of disease transmission, all blood donors should be appropriately screened for infectious disease.

What screening is appropriate? An exhaustive treatise on each infectious disease and its causative agent is not the objective of this article. Rather, our intent is to provide a summary of canine and feline diseases that pose potential risk to transfusion recipients.

The following recommendations are based on the information available at the time of this writing. The area of infectious disease is extremely dynamic, with new organisms being recognized and previously recognized organisms being renamed. For the sake of clarity, the consensus panel subdivided diseases into the following categories for the dog and cat:

1. Vectorborne diseases—testing recommended
2. Nonvectorborne diseases—testing recommended
3. Vectorborne diseases—conditional testing (ie, to be considered)
4. Other diseases—testing not recommended

Diseases for which testing is recommended met at least 3 of the following criteria: (1) the disease agent is documented to cause clinical infection in recipients via blood transmission, (2) the disease agent is capable of causing subclinical infection such that asymptomatic carriers could erroneously be used as blood donors, (3) the disease agent can be cultured from the blood of an infected animal, and (4) the resultant disease in the recipient is severe or difficult to clear. Some of the included diseases also are endemic in restricted areas of North America or occur at higher prevalence in certain breeds, and screening for these diseases outside the endemic region or breed is not routinely recommended.

Diseases for which testing is conditionally recommended (ie, to be considered) met the following criteria: (1) experimental transmission is documented, but clinical transmission via transfusion is not described or (2) the disease does not represent a threat to most recipients or is easily cleared. As our knowledge base grows, and as some diseases become more endemic, diseases which are only to be considered for screening at this time could become diseases for which testing is recommended in the future. Veterinarians using blood donors are advised to read the current literature and recognize potential infectious diseases in their area.

Canine and feline heartworm disease were not included, because they did not meet the criteria for infectious diseases

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that can be transmitted by transfusion (ie, transfusion of microfilaria from an infected donor does not produce heartworm disease in the recipient). For the health of the blood donor, however, dogs and cats in heartworm endemic areas should be tested and placed on preventative therapy.

The consensus panel did not explore frequency of testing, but it seems prudent to retest frequently in endemic areas and to retest donors with repeated exposure to risk factors (eg, tick exposure). The consensus panel agreed that prevention of disease in blood donors and prevention of contamination of collected blood products by management techniques also should be considered, and appropriate recommendations are included in the consensus statement.

General Comments on Infectious Disease Testing

No tests have 100% sensitivity and specificity. Consequently, accurate diagnosis of infectious diseases often requires an integrated approach, including physical examination, hematologic and biochemical testing, and several test methodologies directed at the organism of interest. The following is a brief discussion of the basic utility and limitations of these tests.

Organism or Antigen Tests

Light Microscopy. Documentation of an infectious agent by light microscopy usually is specific, but requires skilled personnel and is time consuming (an adequate blood film examination can take 20–30 minutes). Because false-negative results can occur with blood film scans, potential donors with no microscopic evidence of infection might need to be assessed by other testing methodologies.

Culture. Positive blood culture results indicate the presence of ongoing infection, and the positive predictive value of culture is high. Some infectious agents of interest to transfusion medicine, however, have never been successfully cultured, and culture techniques for some organisms are not commercially available, have poor sensitivity, are expensive, or are time consuming.

Serum Antigen Tests. Assays for detection of antigens of a number of infectious agents are commercially available, and positive results document current infection. *Dirofilaria immitis* (dogs and cats) and feline leukemia virus (FeLV) tests are the serum antigen tests used most frequently for donor screening and health assessment. Point-of-care tests are available for both organisms, and the potential for inaccurate results from operator error is small.

Polymerase Chain Reaction Testing. Polymerase chain reaction (PCR) assays amplify DNA sequences specific for each agent, thereby indicating current infection. The major advantage of PCR assays is that the positive predictive value generally is 100% when the tests are performed correctly. Disadvantages include lack of point-of-care tests; lack of standardization among laboratories, which could result in different sensitivities and specificities; lack of test availability for some infectious agents; and expense. Veterinarians should ask laboratories about the sensitivity, specificity, and detection limits of their PCR tests. False-negative tests can occur with some PCR assays if the DNA is present only in small concentrations. In addition, most PCR tests evaluate a very small sample of blood (microliters), and patients can receive over 10,000 times that amount during a transfusion. In some cases, PCR-negative animals should be further evaluated by repeated PCR tests, serology, or blood culture before inclusion in the donor pool.

Animals that have microscopic evidence of infection, are culture-positive, are antigen-positive, or are positive by PCR assay should be excluded from the donor pool. For some agents, complete information is not available to prove that infection can be eliminated by treatment, and previously positive animals should not be used as blood donors.

Serum Antibody Tests

True positive serum antibody test results document exposure to the agent in question but do not prove current infection. In general, the specificities and negative predictive values of these tests often are very good, but PCR assays might be indicated to further evaluate infectious status of some seronegative animals in endemic areas (see specific agent discussions).

Many techniques are used to detect specific antibodies, including immunofluorescent antibody tests (IFA), enzyme-linked immunosorbent antibody assays (ELISA), western blot immunoassay, agar gel immunodiffusion, and a variety of agglutination and hemagglutination procedures. Gold standard techniques vary from 1 infectious agent to another. IFA and ELISA are used frequently, and results can be expressed as titers or as positive or negative (point-of-care ELISA). Point-of-care ELISAs are available for some infectious agents and have the advantages of being rapid and inexpensive, and the potential for operator error is small. There is no standardization of serological tests for infectious agents offered by commercial laboratories. Differences in antigen, antigen preparation, reagents, and protocol and inherent subjectivity in interpretation of the IFA tests are some disadvantages.

In general, because seropositive animals still might be infected, we recommend exclusion of seropositive animals from the donor pool. Similar to the situation that exists with antigen tests, it often is unknown whether or not treatment has cleared the infection, and previously positive animals should not be used as blood donors. Only in diseases for which the organism is believed to be totally eliminated after treatment of infection, such as in Rocky Mountain Spotted Fever in dogs, can a seropositive, healthy animal be considered for use as a blood donor after recovery from disease.

Screening of Blood Donors for Infectious Disease

Canine Diseases

Vectorborne Diseases—Testing Recommended. *Babesiosis:* Babesiosis is a disease caused by organisms of the genus *Babesia*. *Babesia canis* and *Babesia gibsoni* are the most common species that occur naturally in the dog. The infections normally are transmitted by an infected ixodid tick vector, by perinatal transmission, or by direct transmission via mechanical vectors. Transmission of *Babesia*

sp. by transfusion is well documented in both humans[1,2] and dogs.[3,4] The disease in dogs can be peracute, acute, chronic, or subclinical. A high seroprevalence of *B canis* occurs in Greyhounds,[5] and an increased prevalence of *B gibsoni* occurs in American Pit Bull Terriers and American Staffordshire Terriers, as detected by PCR.[6,7] The consensus of the panel is that potential blood donors, especially greyhounds, American Pit Bull Terriers, and Staffordshire Terriers, be screened for both *B canis* and *B gibsoni.* Serologic testing for antibodies can be performed initially, with seropositive dogs excluded. Seronegative dogs can be additionally screened with PCR for *Babesia* spp.

Leishmaniasis: Leishmaniasis is a disease caused by protozoal organisms of the genus *Leishmania* and is transmitted in Mediterranean regions by the bite of an infected female sand fly. The vector in North America is not known. In the United States, the disease is considered endemic in Texas, Ohio, and Oklahoma[8] but also has been reported in several other states. Several forms of the disease, including cutaneous, mucocutaneous, and visceral forms, have been identified in dogs. Visceral leishmaniasis, caused by *Leishmania donovani,* has been transmitted clinically by blood transfusions in dogs, with clinically healthy foxhounds as blood donors.[9] In 1 study, 30% of English Foxhounds tested were seropositive for *Leishmania* spp.[9] Another study examining the seroprevalence of antibodies against *Leishmania* in the United States found 2 non-foxhound dogs to be seropositive. Both of these dogs had negative test results by PCR assays.[10] Because of the severity of the clinical disease and its known transmission via blood transfusion, it is recommended that all foxhounds and dogs with travel history to or from endemic areas be screened for *Leishmania* spp. As with *Babesia,* screening for *Leishmania* involves initial IFA testing, with seropositive dogs excluded. Seronegative dogs can be screened additionally with *Leishmania* PCR. It should be noted that the IFA for *Leishmania* spp. can cross-react with *Trypanosoma cruzi,* and seropositive animals should also be evaluated for the presence of specific antibody against *T cruzi.*[10]

Ehrlichiosis, Anaplasmosis, Neorickettsiosis: Dogs are known to be infected by a variety of *Ehrlichia* spp., *Anaplasma* spp., and *Neorickettsia* spp. organisms in the family Rickettsiaceae. In general, these organisms are arthropod-borne; several are known to be tickborne. *Ehrlichia canis, Ehrlichia ewingii, Ehrlichia chaffeensis, Anaplasma phagocytophilum* (previously *Ehrlichia equi,* the human granulocytic ehrlichial agent), and *Anaplasma platys* (previously *Ehrlichia platys*) are known to infect dogs naturally and can produce disease. *Neorickettsia risticii* (previously *E risticii* var. *atypicalis*) and *Neorickettsia helmintheca* are the most common organisms in this genera known to infect dogs.[11] Of all of these agents, *E canis* is probably the most commonly described in the dog and causes acute, chronic, and subclinical syndromes. Experimentally, subcutaneous inoculation of the organism, mimicking natural transmission by tick vectors, results in dose-dependent infection and positive blood cultures.[12] Screening of potential blood donor dogs for antibodies against *E canis* can be performed by IFA assay. The consensus of the ACVIM Ehrlichial Disease Infectious Disease Study Group in 2002 was that IFA titers to *E canis* <1 : 80 should be interpreted with caution

because they could be false positives but that titers >1 : 80 were likely to be true positives.[13] For dogs with low titers, repeated serologic testing (within 2–3 weeks), PCR, or Western immunoblotting is recommended. A commercial point-of-care *E canis* enzyme immunoassay (EIA) antibody screening test[a] also is available for screening for *E canis* antibodies. This assay requires a ''threshold'' antibody titer of at least 1 : 100 for positive results. Given the widespread geographical distribution of the disease and its subclinical form, the consensus is that potential blood donor dogs should be screened by IFA or screened with the point-of-care test for *E canis,* and positive animals should be excluded as blood donors. Because cross-reactivity among *E canis, E ewingii,* and *E chaffeensis* might not always occur, dogs that are seronegative for *E canis* antibodies should be additionally screened by genus-specific PCR, especially in those areas where *E ewingii* or *E chaffeensis* are endemic. Individual blood banking programs also might want to pursue further testing with PCR or IFA for other *Anaplasma* or *Neorickettsia* species.

Non-Vectorborne Diseases—Testing Recommended. *Brucellosis:* Brucellosis is a disease caused by the gram-negative bacteria *Brucella canis.* The disease primarily affects the reproductive organs of male and female dogs. Infected female dogs can transmit the organism during breeding or via oronasal contact with vaginal discharge or aborted material. Male dogs can harbor the organism in the prostate and epididymides, and urine and seminal fluid can serve as the source of infection. Transmission via blood transfusion has been documented in humans[14] but not in dogs. However, bacteremia in dogs occurs and isolation of the organism from blood is a technique performed when serologic testing is ambiguous. Experimentally infected dogs have remained blood culture–positive for several years.[15]

Serological screening of potential donors for antibodies by the rapid slide agglutination test (RSAT) should be performed initially, with blood culture, tube agglutination tests, agarose gel immunodiffusion tests, or ELISA tests used for confirmation of infection.[16] All positive dogs should be excluded as blood donors. A single negative RSAT is sufficient for neutered donors, but blood donor programs that include sexually active intact dogs should perform the RSAT.

Vectorborne Diseases—Conditional Testing. *Trypanosomiasis:* American trypanosomiasis, also known as ''Chagas disease,'' is caused by *T cruzi,* a hemoflagellate protozoan with an insect vector. The disease in dogs generally results in either an acute or chronic myocarditis and cardiac failure, but in 1 study,[17] dogs that were experimentally inoculated with a canine isolate of *T cruzi* were parasitemic but developed only transient lymphadenopathy. Survivors of the acute disease can be asymptomatic for several months until chronic myocarditis develops. Infection is characterized by detectable concentrations of specific antibodies and low concentrations of circulating parasites.[18] Most canine cases of trypanosomiasis in the United States occur in Texas or the southwestern region. Transmission by blood transfusion has not been documented in the literature. Dogs with a history of travel to and from endemic areas should be considered for serological screening by IFA, and

seropositive donors should be excluded from the donor pool.

Bartonellosis: Bartonella vinsonii subspecies *berkhoffi* is a vector-transmitted, intraerythrocytic bacteria that has been isolated from dogs with endocarditis, myocarditis, and granulomatous disease. Both affected and clinically healthy dogs can be seropositive.[19,20] Transfusion transmission has not been reported, but chronic infection has resulted from experimental IV inoculation of the organism.[21] Screening is performed by IFA, with a single titer $\geq 1:64$ evidence of prior exposure or infection.[19] *B vinsonii* is a newly emerging organism, and its potential for transmission from blood products is unclear. Therefore, screening of blood donors is only conditionally recommended.

Hemoplasmosis: Mycoplasma haemocanis (formerly *Hemobartonella canis*) is an epicellular parasite of erythrocytes that is transmitted by tick. Unlike cats with hemoplasmosis, the majority of normal dogs infected with *M haemocanis* do not develop clinical evidence of disease. Diagnosis is based on visualization of the organism in erythrocytes (unlikely in carrier dogs) or by PCR assay.[22]

Other Diseases—Testing Not Recommended. *Lyme Disease:* Lyme borreliosis, or Lyme disease, is caused by the spirochete *Borrelia burgdorferi.* Ticks of the *Ixodes* spp. are known vectors.[23] Although most infections in dogs likely are inapparent, the most common clinical sign in dogs is lameness as a result of polyarthritis. Fever, lymphadenopathy, and glomerulonephritis also are described. Widespread seropositivity exists in some areas of the United States, especially in the northeastern region.[24] Currently, disease transmitted by transfusion has not been reported. Despite the ability to culture *B burgdorferi* from human blood,[25] a study in humans demonstrated that the risk of acquiring Lyme disease from a transfused unit of packed red blood cells or platelets was negligible.[26] In a study in dogs, only 1.6% of 576 blood samples from experimentally infected dogs was positive for *B burgdorferi* by PCR.[27] The consensus of the panel is that healthy canine blood donors do not require screening for *B burgdorferi.*

Rocky Mountain Spotted Fever: Rocky Mountain Spotted Fever (RMSF) is a tickborne rickettsial disease affecting dogs and humans. The causative organism is *Rickettsia rickettsii.* RMSF is associated with retinal or cutaneous hemorrhages, epistaxis, melena, hematuria, and other clinical findings. The organism is eliminated from dogs after infection, and chronic carrier states have not been reported. The consensus of the panel is that healthy blood donors do not need to be screened for RMSF, because infected dogs are acutely ill and no asymptomatic carrier state is known to exist.

Feline Diseases

Vectorborne Diseases—Testing Recommended. *Hemoplasmosis: Hemobartonella felis,* a hemotrophic organism known to produce anemia in infected cats, recently has been reclassified to the genus *Mycoplasma.* Genetic studies of *H felis* have identified at least 2 different strains, now known as *Mycoplasma haemofelis* (Ohio or large form) and *Candidatus Mycoplasma haemominutum* (California or small form).[28] Differences in pathogenicity between the 2 strains

still are being defined, but it appears that *M haemofelis* is the more virulent organism.[29–31] Cats that recover from infection can remain chronic carriers.[28,29] Natural routes of transmission still are being determined, but fleas are a likely vector. In a recent study, 22.7% of cats (with a history of flea infestation) used as blood donors in the United States with a history of flea infestation was PCR positive.[32] Intravenous inoculation of infected blood has been used to produce experimental infections.[33] No serologic assay for the disease is commercially available. Although blood smear examination for the organism on the surface of erythrocytes has been used to detect active infections, the organisms are unlikely to be apparent in the chronically infected, asymptomatic cats. The organisms can be detected by light microscopy or with the use of commercially available PCR assays, and microscopy or PCR-positive cats should be excluded from the donor pool.

Bartonellosis: Bartonella spp. are gram-negative, intraerythrocytic bacteria from the family Bartonellaceae. Cats serve as a reservoir for a number of *Bartonella* species, including *Bartonella henselae, Bartonella clarridgeiae,* and *Bartonella koehlerae.* Infected cats typically have a prolonged, asymptomatic bacteremia, but uveitis and endocarditis have been reported.[34,35] Fleas can harbor the organism and are believed to be the likely vector.[36] Natural transmission of *B henselae* by blood transfusion is likely because the organism is an intraerythrocytic bacterium,[37] but cases of bartonellosis resulting from clinical transfusion have not been reported. Bacteremia can be produced experimentally in cats after transmission of infected blood.[38] Transmission of some *Bartonella* species from infected cats to humans does occur, with cat scratch fever the most frequently documented *B henselae*–induced disease.[39] Blood culture or PCR are used to detect current infection, and serology provides evidence of previous or current infection. One study in the United States and western Canada showed a seroprevalence for *B henselae* of 27.9% in 628 pet cats, with regional variability.[40] Another study showed that *B henselae* and *B clarridgeiae* bacteremia was found in up to 50% of the domestic and feral cat populations in regions where fleas were endemic.[41] However, *B henselae* infection was only documented by PCR assay in 2 of 117 (1.7%) community source cats used as blood donors in the United States.[32] Serologic cross-reactivity among *B henselae* and *B clarridgeiae* and *B koehlerae* does not always occur, but blood culture and PCR are capable of detecting all *Bartonella* species. Although sensitive, blood culture can take up to 4–6 weeks to perform, and bacterial isolates require molecular characterization such as PCR or DNA sequencing to confirm their identity. Treatment does not consistently lead to elimination of the organism.[42]

The panel was divided on screening recommendation for *Bartonella.* All authors felt it would be ideal to strive for a *Bartonella*-free donor pool, but several factors, including the potential pathogenicity and epidemiology of feline bartonellosis, led to a division of the panel on whether or not to categorize feline bartonellosis in the recommended or conditional group. Four of 7 authors recommended routine screening of feline blood donors, with seropositive, PCR-positive or blood culture–positive cats excluded from donation. Three of 7 authors felt that the lack of current in-

formation on the pathogenicity of the organism and the possibility of a high prevalence of pre-existing infections in some areas warranted a conditional recommendation.

Non-Vectorborne Diseases—Testing Recommended. *FeLV Infection:* FeLV is an oncornavirus that causes a variety of neoplastic and nonneoplastic diseases in cats. Transmission of the virus occurs primarily through saliva, but the virus is present in the blood and can be transmitted by blood transfusion.[43] Testing of donor cats for the FeLV antigen by ELISA is recommended, and all seropositive cats should be excluded from blood donation. Free-roaming cats have constant potential exposure and should be excluded from blood donor programs.

Feline Immunodeficiency Virus Infection: The feline immunodeficiency virus (FIV) is a lentivirus transmitted by exposure to the virus in saliva or blood.[44] Testing of donor cats for FIV-specific antibodies by ELISA is recommended, and all seropositive cats should be excluded. Cats vaccinated against FIV also will be seropositive, and other serological or PCR tests that definitively discriminate between vaccinated and nonvaccinated FIV-positive cats are not available.[45,46] It is recommended therefore that all seropositive cats, including vaccinated cats, be excluded from the donor pool. Free-roaming cats should also be excluded from donor programs.

Vectorborne Diseases—Conditional Testing. *Cytauxzoonosis: Cytauxzoon felis* is a tickborne organism in the order Piroplasmida and family Theileriidae. The organism infects erythrocytes and can be transmitted experimentally via blood.[47] The fatal form of the disease develops after tick transmission of the organism or after experimental administration of infected tissue homogenates. In naturally occurring disease, the majority of infected cats develop severe anemia and die within 5 days. A chronic carrier state has been identified in Arkansas and Tennessee.[48] No commercially available serologic or PCR test is available for *C felis,* and blood smears must be examined for the signet-shaped piroplasm in erythrocytes. Because the majority of infected cats are ill and the carrier state is geographically limited, the disease is considered of low priority when screening clinically healthy cats as potential blood donors. Use of indoor cats and appropriate ectoparasite prophylaxis are advised to avoid this disease in donor animals.

Ehrlichiosis, Anaplasmosis, Neorickettsiosis: An *E canis*–like infection and *A phagocytophilum* infections of cats have been described, with PCR amplification of the organism from blood.[49–51] In 1 study with healthy blood donor cats, DNA from these genera could not be detected.[32] *Neorickettsia risticii* can infect experimentally inoculated cats but has not been grown or amplified from naturally exposed cats.[52]

Screening for these organisms in healthy cats to be used as blood donors is not routinely recommended at this time, but veterinarians in areas where known infections with these agents have occurred should consider testing of their blood donors.

Other Diseases—Testing Not Recommended. *Feline Infectious Peritonitis:* Several enteric coronaviruses occur in cats. Feline infectious peritonitis is a terminal disease of cats caused by a mutant form of feline enteric coronavirus. Documentation of clinical transmission of the disease by blood transfusion does not exist at this time. Screening of blood donor cats with serology or reverse transcriptase (RT)-PCR is not recommended, because healthy cats can have antibody titers against the enteric coronavirus and can also be RT-PCR positive. The consensus of the panel was not to screen for coronavirus antibodies or RNA in clinically healthy cats being considered as blood donors.

Toxoplasmosis: Cats are the definitive host for *Toxoplasma gondii,* an intracellular coccidian parasite. *Toxoplasma* oocyts are excreted in feces, whereas tachyzoites and bradyzoites are found in tissues. Transmission occurs by ingestion of infected tissues or ingestion of oocyst-contaminated food or water. Although *T gondii* antigens and DNA have been detected in healthy cats by PCR assay, transmission by blood transfusion has not been documented.[53] For purposes of blood safety, the consensus of the panel is that there is no indication for screening healthy potential donor cats for *T gondii* antigens, antibodies, or DNA.

General Recommendations

Tables 1 and 2 indicate those tests that are highly recommended for the screening of blood donors and tests that should be considered. Note that some of the diseases are restricted to certain geographic regions or have higher prevalence in certain breeds.

The consensus panel hopes that its findings will lead to re-evaluation of the current infectious disease screening process for potential dog and cat donors. Diagnostic laboratories should reexamine their donor screening panels, offering assays for those diseases that are of most concern in bloodborne disease transmission.

Management Techniques

The panel agreed on several management techniques designed to decrease the risk of disease transmission via blood transfusion.

Donor Selection and Care

1. A complete history of the donor animal should be taken before each blood collection. History of travel to an area endemic for transmissible disease agents or exposure to known risk factors for infection should prompt further testing. History of recent illness should result in cessation of blood collection until the nature of the illness is determined. Indoor cats allowed to go outdoors can require repeat testing.

2. A thorough physical examination, including temperature, should be performed before each blood collection. The donor also can be examined at this time for the presence of any fleas or ticks, which might cause exclusion from the program if they are present. If required for the region, ectoparasite prophylaxis should be performed to minimize exposure to potential vectors.

3. Standardized forms should be available to the owners of volunteer donors, asking them to report whether the animal becomes ill within 48 hours of donation and asking about travel history.

4. Prophylactic antibiotics, such as low-dose doxycycline

Table 1. Recommendations for infectious disease screening of healthy canine blood donors.

Disease	Disease Agent(s)	Screening	Tests[a]
Babesiosis	*Babesia canis, B gibsoni*	Recommended[b]	IFA, PCR
Leishmaniasis	*Leishmania donovani*	Recommended[b]	IFA, PCR
Ehrlichiosis	*Ehrlichia canis*	Recommended	IFA, ELISA, PCR
	E ewingii, E chaffeensis	Conditional	PCR
Brucellosis	*Brucella canis*	Recommended	RSAT, TAT
Anaplasmosis	*Anaplasma phagocytophilum,*	Conditional	IFA, PCR
Neorickettsiosis	*A platys*		
	Neorickettsia risticii		
	N helmintheca		
Trypanosomiasis	*Trypanosoma cruzi*	Conditional[b]	IFA
Bartonellosis	*Bartonella vinsonii*	Conditional	IFA

ELISA, enzyme-linked immunosorbent assay; IFA, immunofluorescent antibody; PCR, polymerase chain reaction; RSAT, rapid slide agglutination test; TAT, tube agglutination test.

[a] See text for more specific recommendations.

[b] Geographic or breed restrictions might apply.

or tetracycline, are not acceptable in lieu of testing for blood donors. Heartworm and ectoparasite prophylactics are acceptable for blood donors.

5. Initial clinicopathologic screening of the donor is advised (CBC, serum chemistries, urinalysis, and fecal examination). Determination of PCV is advised before each collection to ensure blood products with adequate red blood cells for transfusion and to protect the donor from anemia secondary to repeated donations.

Blood Collection Procedure Recommendations

1. All blood for transfusion should be collected in an aseptic manner.
2. Before administration, the label of the blood product should be examined for the following: expiration date, donor species, product type, blood type.
3. Before administration, the blood products should be visually inspected. Bacterial contamination should be suspected if bag segments appear much lighter in color than the bag itself, the red blood cell mass appears purple, a zone of hemolysis is observed just above the red cell mass, clots are visible, or the plasma or supernatant fluid

is murky, purple, brown or red. In the presence of any of these findings, culture should be performed to determine whether contamination has occurred. If the unit appears abnormal, it should not be administered.

4. Currently, veterinarians cannot rely on screening of individual units for infectious disease because of the turnaround time and costs of available tests. However, this model should be considered the gold standard, and we should continue to encourage industry to develop this technology.

5. An aliquot of plasma should be stored from each donated unit of blood. This practice would allow retrospective testing in cases of suspected transfusion-associated disease transmission.

Records

1. Records should be kept on all transfusions, documenting both the donor unit used and the recipient given the transfusion. A standardized transfusion form can be helpful. Appropriate records must be kept so that all recipients receiving blood from a given donor can be

Table 2. Recommendations for infectious disease screening of healthy feline blood donors.

Disease	Disease Agent(s)	Screening	Tests[a]
Feline leukemia virus (FeLV) infection	FeLV	Recommended	ELISA
Feline immunodeficiency virus (FIV) infection	FIV	Recommended	ELISA
Hemoplasmosis	*Mycoplasma haemofelis, M haemominutum*	Recommended	Microscopy, PCR
Bartonellosis	*Bartonella henselae, B clarridgeae, B kholerae*	Recommended/ Conditional[a]	IFA, PCR, culture
Cytauxzoonosis	*Cytauxzoon felis*	Conditional[b]	Microscopy
Ehrlichiosis	*Ehrlichia canis*–like	Conditional	PCR
Anaplasmosis	*Anaplasma phagocytophilum*	Conditional	IFA, PCR
Neorickettsiosis	*Neorickettsia risticii*		

ELISA, enzyme-linked immunosorbent assay; IFA, immunofluorescent antibody; PCR, polymerase chain reaction.

[a] See text for more specific recommendations.

[b] Geographic or breed restrictions might apply.

easily contacted should that donor be found to carry an infectious disease agent.

2. Consent forms for owners of patients receiving transfusions should be considered. These forms should provide information to the owner detailing the risks of transfusions and should indicate that blood banks and veterinarians cannot guarantee a disease-free product.

Summary

Thousands of blood transfusions are performed each year on dogs and cats, and the demand for blood products continues to grow. Risks associated with transfusions include the risk of disease transmission. Appropriate screening of blood donors for bloodborne infectious disease agents should be performed to lessen this risk. Geographic restrictions of disease, breed predilection, and documentation of actual disease transmission by transfusion all are factors that might need to be considered when making a decision on what screening program to use. In addition, factors involving general health care and management of blood donors should be employed to further ensure blood safety.

Footnote

References

1. Herwaldt BL, Neitzel DF, Gorlin JB. Transmission of *Babesia microti* in Minnesota through four blood donations from the same donor over a 6 month period. Transfusion 2002;42:1154–1158.

2. Dobroszycki J, Herwaldt BL, Boctor F. A cluster of transfusion-associated babesiosis cases traced to a single asymptomatic donor. J Am Med Assoc 1999;281:927–930.

3. Freeman MJ, Kirby BM, Panciera DL, et al. Hypotensive shock syndrome associated with acute *Babesia canis* infection in a dog. J Am Vet Med Assoc 1994;204:94–96.

4. Stegeman JR, Birkenheuer AJ, Kruger JM, et al. Transfusion-associated *Babesia gibsoni* infection in a dog. J Am Vet Med Assoc 2003;222:959–963.

5. Taboada J, Harvey JW, Levy MG, et al. Seroprevalence of babesiosis in Greyhounds in Florida. J Am Vet Med Assoc 1992;200:47–50.

6. Macintire DK, Boudreaux MK, West GD, et al. *Babesia gibsoni* infection among dogs in the southeastern United States. J Am Vet Med Assoc 2002;220:325–329.

7. Birkenheuer AJ, Levy MG, Stebbins M, et al. Serosurvey of anti-Babesia antibodies in stray dogs and American Pit Bull Terriers and American Staffordshire Terriers from North Carolina. J Am Anim Hosp Assoc 2003;39:551–557.

8. Bravo L, Frank LA, Brenneman KA. Canine leishmaniasis in the United States. Compend Cont Educ Pract Vet 1993;15:699–708.

9. Owens S, Oakley D, Marryott K, et al. Transmission of visceral leishmaniasis through blood transfusions from infected English Foxhounds to anemic dogs. J Am Vet Med Assoc 2001;219:1081–1088.

10. Grosjean NL, Vrable RA, Murphy AJ, et al. Seroprevalence of antibodies against *Leishmania* spp among dogs in the United States. J Am Vet Med Assoc 2003;222:603–606.

11. Dumler JS, Barbet AF, Bekker CP, et al. Reorganization of genera in the families Rickettsiaceae and Anaplasmataceae in the order Rickettsiales: Unification of some species of *Ehrlichia* with *Anaplas-ma, Cowdria* with *Ehrlichia* and *Ehrlichia* with *Neorickettsia,* descriptions of six new species combinations and designation of *Ehrlichia equi* and HGE agent as subjective synonyms of *Ehrlichia phagocytophila.* Int J Syst Evol Microbiol 2001;51:2145–2165.

12. Gaunt SD, Corstvet RE, Berry CM, et al. Isolation of *Ehrlichia canis* from dogs following subcutaneous inoculation. J Clin Microbiol 1996;34:1429–1432.

13. Neer TM, Breitschwert EB, Greene RT, et al. Consensus statement of ehrlichial disease of small animals from the Infectious Disease Study Group of the ACVIM. J Vet Intern Med 2002;16:309–315.

14. al-Kharfy TM. Neonatal brucellosis and blood transfusion: Case report and review of the literature. Ann Trop Paediatr 2001;21:349–352.

15. Carmichael LE, Greene CE. Canine brucellosis. In: Greene CE, ed. Infectious Disease of the Dog and Cat. Philadelphia, PA: WB Saunders; 1998:248–257.

16. Wanke MM. Canine brucellosis. Anim Reprod Sci 2004;82–83:195–207.

17. Barr SC, Gossett KA, Klei TR. Clinical, clinicopathologic, and parasitologic observations of trypanosomiasis in dogs infected with North American *Trypanosoma cruzi* isolates. Am J Vet Res 1991;52:954–960.

18. Bradley KK, Bergman DK, Woods JP. Prevalence of American trypanosomiasis (Chagas disease) among dogs in Oklahoma. J Am Vet Med Assoc 2000;217:1853–1857.

19. Breitschwerdt EB, Blann KR, Stebbins ME, et al. Clinicopathological abnormalities and treatment response in 24 dogs seroreactive to *Bartonella vinsonii* (*berkhoffii*) antigens. J Am Anim Hosp Assoc 2004;40:92–101.

20. Honadel TE, Chomel BB, Yamamoto K, et al. Seroepidemiology of *Bartonella vinsonii* subsp *berkhoffii* exposure among healthy dogs. J Am Vet Med Assoc 2001;219:480–484.

21. Pappalardo BL, Brown TT, Tompkins M, et al. Immunopathology of *Bartonella vinsonii* (*berkhoffii*) in experimentally infected dogs. Vet Immunol Immunopathol 2001;83:125–147.

22. Brinson J, Messick J. Use of a polymerase chain reaction assay for detection of *Haemobartonella canis* in a dog. J Am Vet Med Assoc 2001;218:1943–1945.

23. Fritz CL, Kjemtrup AM. Lyme borreliosis. J Am Vet Med Assoc 2003;223:1261–1270.

24. Magnarelli LA, Anderson JF, Schreier AB. Persistence of antibodies to *Borrelia burgdorferi* in dogs in New York and Connecticut. J Am Vet Med Assoc 1990;196;1064–1068.

25. Wormser GP, Bittker S, Cooper D, et al. Yield of large-volume blood cultures in patients with early Lyme disease. J Infect Dis 2001;184:1070–1072.

26. Gerber MA, Shapiro ED, Krause PJ, et al. The risk of acquiring Lyme disease or babesiosis from a blood transfusion. J Infect Dis 1994;170:231–234.

27. Straubinger RK. PCR-based quantification of *Borrelia burgdorferi* organisms in canine tissues over a 500-day postinfection period. J Clin Microbiol 2000;38:2191–2199.

28. Messick JB. Hemotrophic mycoplasmas (hemoplasmas): A review and new insights into pathogenic potential. Vet Clin Pathol 2004;33:2–13.

29. Foley JE, Harrus S, Poland A, et al. Molecular, clinical, and pathologic comparison of two distinct strains of *Haemobartonella felis* in domestic cats. Am J Vet Res 1998;59:1581–1588.

30. Jensen WA, Lappin MR, Kamkar S, et al. Use of a polymerase chain reaction assay to detect and differentiate two strains of *Haemobartonella felis* in naturally infected cats. Am J Vet Res 2001;62:604–608.

31. Westfall DS, Jensen WA, Reagan W, et al. Inoculation of two genotypes of *Haemobartonella felis* (California and Ohio variants) to induce infection in cats and response to treatment with azithromycin. Am J Vet Res 2001;62:687–691.

32. Hackett TB, Jensen WA, Lehman T, et al. Prevalence of *My-

coplasma spp.,*Bartonella* spp., *Ehrlichia* spp., and *Anaplasma phag-ocytophilum* DNA in blood of cats used as blood donors in the United States. J Am Vet Med Assoc In review, 2004.

33. Berent LM, Messick JB, Cooper SK. Detection of *Haemobartonella felis* in cats with experimentally induced acute and chronic infections, using a polymerase chain reaction assay. Am J Vet Res 1998;59:1215–1220.

34. Lappin MR, Black JC. *Bartonella* spp infection as a possible cause of uveitis in a cat. J Am Vet Med Assoc 1999;214:1205–1207.

35. Chomel BB, Wey AC, Kasten RW, et al. Fatal case of endocarditis associated with *Bartonella henselae* type I infection in a domestic cat. J Clin Microbiol 2003;41:5337–5339.

36. Finkelstein JL, Brown TP, O'Reilly KL, et al. Studies on the growth of *Bartonella henselae* in the cat flea (Siphonaptera: Pulicidae) J Med Entomol 2002;39:915–919.

37. Rolain JM, Locatelli C, Chabanne L, et al. Prevalence of *Bartonella clarridgeiae* and *Bartonella henselae* in domestic cats from France and detection of the organisms in erythrocytes by immunofluorescence. Clin Diagn Lab Immunol 2004;11:423–425.

38. Kordick DL, Breitschwerdt EB. Relapsing bacteremia after blood transmission of *Bartonella henselae* to cats. Am J Vet Res 1997;58:492–497.

39. Windsor JJ. Cat-scratch disease; epidemiology, aetiology and treatment. Br J Biomed Sci 2001;58:101–110.

40. Jameson P, Greene C, Regnery R, et al. Prevalence of *Bartonella henselae* antibodies in pet cats throughout regions of North America. J Infect Dis 1995;172:1145–1149.

41. Heller R, Artois M, Xemar V, et al. Prevalence of *Bartonella henselae* and *Bartonella clarridgeiae* in stray cats. J Clin Microbiol 1997;35:1327–1331.

42. Kordick DL, Papich MG, Breitschwerdt EB. Efficacy of enrofloxacin or doxycycline for treatment of *Bartonella henselae* or *Bartonella clarridgeiae* infection in cats. Antimicrob Agents Chemother 1997;41:2448–2455.

43. Hardy WD, Hess PW, Essex M, et al. Horizontal transmission of feline leukemia virus in cats. Bibl Haematol 1975;40:67–74.

44. Callanan J, Thompson H, Toth S, et al. Clinical and pathological findings in feline immunodeficiency virus experimental infection. Vet Immunol Immunopathol 1992;35:3–13.

45. Levy JK, Crawford PC, Slater MR. Effect of vaccination against feline immunodeficiency virus on serological testing. J Am Vet Med Assoc 2004. In press.

46. Crawford PC, Slater MR, Leutenegger CM, Levy JK. PCR for diagnosis of FIV infection. J Am Vet Med Assoc 2004. In press.

47. Wagner JE, Ferris DH, Kier AB, et al. Experimentally induced cytauxzoonosis-like disease in domestic cats. Vet Parasitol 1980;6:305–311.

48. Meinkoth J, Kocan AA, Whitworth L, et al. Cats surviving natural infection with *Cytauxzoon felis*: 18 cases (1997–1998). J Vet Intern Med 2000;14:521–525.

49. Breitschwert EB, Abrams-Ogg AC, Lappin MR, et al. Molecular evidence supporting *Ehrlichia canis*-like infection in cats. J Vet Intern Med 2002;16:642–649.

50. Lappin MR, Breitschwerdt EB, Jensen WA, et al. Molecular and serological evidence of *Anaplasma phagocytophilum* infection of cats in North America. J Am Vet Med Assoc 2004. In press.

51. Bjoersdorff A, Svendenius L, Owens JH, et al. Feline granulocytic ehrlichiosis—A report of a new clinical entity and characterization of the infectious agent. J Sm Anim Pract 1999;40:20–24.

52. Dawson JE, Abeygunawardena I, Holland CJ, et al. Susceptibility of cats to infection with *Ehrlichia risticii,* causative agent of equine monocytic ehrlichiosis. Am J Vet Res 1988;49:2096–2100.

53. Burney DP, Spilker M, McReynolds L, et al. Detection of *Toxoplasma gondii* parasitemia in experimentally inoculated cats. J Parasitol 1999;5:947–951.