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Frequencies of blood types A, B, and AB in non-pedigree domestic cats in Beijing

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Abstract

Background—Blood type A, B, and AB frequencies in domestic cats vary geographically and among breeds. Frequencies of feline blood types in China have not been reported.

Objective—The purpose of this study was to survey the frequency of blood types in domestic cats in the Beijing area.

Methods—A total of 262 cats from the city of Beijing were blood-typed using a standard tube agglutination assay. All cats were non-pedigree domestic shorthaired and longhaired cats; purebred cats were excluded. Serum obtained from type B cats and a lectin (*Triticum vulgare*) solution served as anti-A and anti-B reagents, respectively. The presence of alloantibodies was also determined in some cats.

Results—The frequency of blood types was 88.2% type A, 11.4% type B, and 0.4% type AB. The tube assay resulted in 3+ to 4+ agglutination reactions with either the anti-A or anti-B reagents. The one type-AB sample showed 3+ agglutination with both anti-A and anti-B reagents; the plasma of that sample did not react with either type-A or type-B RBCs. Tested type-B cats had strong anti-A antibodies.

Conclusions—The frequency of blood type B in the Beijing area was relatively high and similar to that reported for other Asian countries and Australia. Blood-typing is recommended to match donors and recipients before transfusion therapy and planned matings to avoid hemolytic transfusion and neonatal isoerythrolysis reactions, respectively, due to blood type incompatibility.

Keywords

DLH; DSH; feline; neonatal isoerythrolysis; transfusion reaction

Introduction

The most important feline blood group system is the AB system which comprises blood types A, B, and the extremely rare AB.¹ The inheritance pattern is regulated by a set of 3 alleles, a, b, and ab; a and ab are dominant over b, whereas ab is recessive to a.²⁻³ Type AB cats are not the result of matings between type-A and B cats unless the type-A cat carries

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one of the rare ab alleles.²⁻³ The difference in type A and type B is caused by a mutation in cytidine monophospho-N-acetylneuraminic acid hydroxylase which converts N-acetylneuraminic acid to N-glycolylneuraminic acid in type-A cats, but it is still uncertain how the AB blood type arises.⁴

In contrast to blood group systems in people and other species, cats have naturally occurring alloantibodies against the RBC AB antigens they lack; thus, the feline AB system bears a distinct similarity to the human ABO system. As expected, type-AB cats do not have any alloantibodies^{1,5}; however, all type-B cats develop high-titer anti-A alloantibodies at a few weeks of age, whereas only a small proportion of type-A cats have measurable titers of anti-B alloantibodies. Hence, life-threatening hemolytic transfusion reactions may occur when AB-mismatched blood is transfused.⁶⁻⁸ Moreover, type-A or type-AB kittens born to a type-B queen and receiving anti-A alloantibodies through colostrum during the first 16 hours of life are at risk for developing life-threatening neonatal isoerythrolysis (NI).⁹⁻¹¹

Type A is the predominant blood type and type-B frequencies vary depending on breed and geographic area; type-AB cats are rarely encountered, comprising <1% of feline populations. The largest variations in A and B blood type frequencies are observed in different breeds of pedigree purebred cats. The frequency of blood type B can reach 25-50% in some breeds, such as the Turkish Van and Turkish Angora, Cornish and Devon Rex, and British and Exotic shorthair, whereas other breeds, such as the Siamese, seem to have no b allele. These frequencies seem to be similar worldwide, likely owing to international travel and breeding, but they may vary between catteries as some select for a particular blood type to reduce NI.^{2,11}

Based upon several surveys, distribution of type-A and B blood types among non-pedigree domestic cats varies geographically. In the US, frequency of type-A and B domestic shorthaired (DSH) and some domestic longhaired (DLH) cats also varies between regions; frequency of type-A cats is 98% across the US, $\geq 99\%$ in the northeast US, and 90-97% on the west coast.² Among DSH cats the frequency of type B is highest in Australia, reaching 24% in Brisbane¹ and 36% in Sydney.¹² Many European countries have been surveyed in the past 60 years, and the frequency of type B varies from 0-25%.^{10,13-17}

Little is currently known about blood-type frequency in Asia. In Japan and South Korea 90.3 and 96.4%, respectively, of domestic cats had type-A blood, and type-AB cats were not detected.^{18,19} Although the distribution of cats with type-AB and B blood in India was reported as 11 and 1%, respectively,²⁰ these findings are inconsistent with the rarity of type-AB cats reported in other surveys, and these cats are found only in populations with a considerable proportion of type-B cats. The objective of this study was to determine the frequency of blood types in non-pedigree domestic cats in Beijing, China in order to estimate the potential risk of adverse incompatibility reactions.

Materials and Methods

Animals

A total of 262 DSH and DLH cats from Beijing were typed at the China Agricultural University (CAU) in Beijing with institutional animal care and use committee approval. Purebred cats were excluded from the study as they are rare and likely represent recent imports; thus, they should have blood type frequencies similar to those already reported.^{2,11}

The cats from Beijing consisted of a group of 111 privately owned indoor cats presented for examination to the CAU Veterinary Teaching Hospital and 151 healthy outdoor stray cats presented for neutering to the local Stray Animal Care Association, a project organized by

CAU Faculty of Veterinary Medicine in order to control the population of stray cats. The privately owned cats ranged in age from 5 months to 18 years; all stray cats were adults.

Blood-typing

Blood had been collected into tubes containing EDTA for routine diagnostic testing. The sample that remained following testing comprised 0.3-1 mL and was stored at 4°C for < 1 month and used for subsequent blood-typing as previously described.^{2,21} Briefly, RBCs were separated from plasma by centrifugation at 2500g for 5 minutes. Plasma was stored at -20°C for < 6 months for alloantibody testing. RBCs were washed twice with phosphate-buffered saline (PBS) and resuspended in PBS to obtain a 2-5% RBC suspension. Serum from type-B cats and the lectin *T. vulgaris* were used as anti-A and anti-B reagents, respectively. Fifty µL anti-A reagent, anti-B reagent, and PBS as an autoagglutination control were added to 3 different tubes, and then 25 µL of the RBC suspension were added to each tube. The tubes were gently mixed, incubated for 15 minutes at 20°C, and then centrifuged at 1500g for 15 seconds. Finally, tubes were gently agitated to resuspend the non-agglutinating RBCs and the degree of agglutination was scored as 0 to 4+ and recorded. For detection of alloantibodies, the back-typing method was used by incubating 50 µL plasma from some tested cats with 25 µL of a 2-5% suspension of known type-A or B RBCs and processed and analyzed as above.^{2,3}

Statistical analysis

The estimated frequency of the risk of acute hemolytic transfusion reactions and of mating risk for NI was calculated using the Hardy-Weinberg equation, as previously described.² All data were assessed by chi-square analysis, and significance was set at $P < .05$. Statistical analyses were performed using the software package SAS, version 9.1 (SAS Institute Inc., Cary, NC, USA).

Results

Of the 262 domestic cats from the city of Beijing typed, nearly equal proportions were males and females and DSH and DLH cats (Table 1). Type A was the predominant blood type at 88.2%, and the frequency of type B was 11.4%. There was 1 type-AB cat (0.4%), a male DLH cat, but information about its origin, parentage, or littermates was not available. There were no significant differences between blood types and the age and sex of the cats ($P = .09$). Similarly there was no difference between distribution of blood types DSH and DLH cats (Table 1) or among privately owned or shelter cats (data not shown, $P > .75$).

Results of the tube-typing assay were clear with either negative reactions or 3+ to 4+ agglutination reactions using either the anti-A or anti-B reagents. For the type-AB cat, 3+ agglutination with both anti-A and anti-B reagents was observed. Back-typing revealed strong agglutination of known type-A RBCs with plasma from cats typed as type B (for 2 type-B cats plasma was not available), but no agglutination with plasma from the type-AB cat with either A or B RBCs. A few samples from type-A cats were back-typed, and none had any appreciable anti-B alloantibodies.

Based on these frequencies the risk of blood-type incompatible matings among domestic cats in Beijing was 10.1% and the risk of receiving a transfusion that could cause an acute hemolytic reaction was 20.2%; this risk was reduced to 11.4% if only cats with type-A blood were used as donors.

Discussion

Cats were reportedly imported into China > 3000 years ago and have been kept as pets since the Tang Dynasty (618-907 AD).²² Chinese domestic cats were believed to have originated from the Indian *Felis ornata*, one subspecies of *Felis silvestris*, from which domestic cats were derived worldwide; they were originally domesticated in the Near East about 9000 years ago.^{22,23} As in other countries, Chinese domestic cats have either short (DSH) or medium-length hair (DLH) coats and are now kept as family pets or for rodent control on farms in China. DSH and DLH cats did not differ in distribution of blood types, an interesting finding as purebred longhaired cats have been reported to have a higher frequency of blood type B than purebred shorthaired cats.^{2,11} Interestingly, the proportion of DLH and DSH cats was similar and thus proportionally included more DLH cats than noted in surveys from other countries. For instance, the percentage of blood samples from DLH cats was 6.7% in the US,²⁴ 6.6% in Turkey,¹⁴ 10.2% in Portugal,²⁵ 15.0% in Greece,²⁶ 10.1% in the UK,¹³ and 0% in South Korea.¹⁸ Although we did not select for or against cats of a particular coat length, other studies may have selected for DSH cats. Moreover, as the population we surveyed was relatively small, the actual frequency of DSH and DLH cats in Beijing, or in China, cannot be inferred. Within the city, non-pedigree domestic cats are generally kept indoors, but there is also a large and growing stray population. As many stray cats are adopted as pets and privately owned indoor cats sometimes escape their home and become stray cats, it was not surprising that blood-type frequencies of privately owned and stray cats were similar in our study.

Similar to results from other geographic locations, type A was the predominant blood type in cats from Beijing. The proportion of type-B cats was relatively high, but only slightly higher than that reported from other Asian countries, such as Japan¹⁹; blood types in South Korea may be similar to those reported in India if the percentages of type-B and AB cats were reversed in the report as discussed below.¹⁸ Type-B frequencies of 10-15% have been reported in a few European countries, such as France and Italy.¹⁶ Surveys from Brisbane and Sydney in Australia have reported the highest frequencies of type-B cats (24% and 36%, respectively).¹² It remains to be determined if the relatively high type-B frequency reported in our study is characteristic of cats in China or is limited to cats in Beijing.

Blood-type AB was rare similar to what has been reported in most surveys, with the exception of the report from India.²⁰ Blood-type AB reflects a unique inheritance pattern in cats that does not result from A × B mating; rather, it is attributed to additional alleles that permit co-expression of A and B RBC antigens.²⁻⁴ As the AB blood type only occurs when a type-AB cat is mated to a type-AB or B cat, type-AB cats are expected only when type-B cats comprise a considerable proportion of the feline population. As other surveys do not indicate that type-AB frequencies can approximate type-B frequencies,^{1-4,24} we surmise that type-AB cats reported from India were actually type-B cats and the few type-B cats represented type-AB cats.

As all mature type-B cats have high anti-A agglutinating titers in their plasma and are at risk for transfusion reactions if typing is not performed. Even though the risk of incompatible transfusions is lower if only type-A cats are used as donors, the risk can be nearly eliminated when both donor and recipient are typed and only blood of a compatible blood type is administered. Thus, typing of donor and recipient is highly recommended.

In cats, the fetus is protected from transplacental antibody transfer from the queen owing to the epithelioendothelial placenta; however, both colostrum and milk from type-B queens contains strong anti-A alloantibodies that can cause severe NI in newborn type-A and AB kittens. In contrast, type-A and AB queens do not have any anti-B alloantibodies in their

colostrum and thus type-B neonates are not at risk. Random matings of non-pedigree cats occur, and even kittens in the first litter born to a type-B queen are at risk for NI; however, not every type-A and AB kitten born to a type-B queen undergoes NI, presumably because of insufficient colostrum intake during the first 16 hours of life or because of premature closure of the neonate's gastrointestinal tract for absorption of intact antibodies.^{9,11} NI has not yet been reported in Beijing, but may not have been detected as veterinarians are rarely asked to evaluate fading neonates. However, our studies clearly indicate that blood-typing should be performed for planned breedings to minimize the occurrence of NI during.

In conclusion, blood type differences represent polymorphisms in a population and may have major clinical implications. It is recommended that AB blood-typing be performed before transfusion therapy and planned matings. Simple in-practice AB typing kits have become available for feline typing.²⁷

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Table 1

Distribution of blood types and estimated proportion of matings at risk for neonatal isoerythrolysis or A-B mismatched transfusions in 262 DSH and DLH cats in Beijing.

Breed and sex	Number of cats	Type A n (%)	Type B n (%)	Type AB n (%)	B allele frequency q^*	Proportion of matings at risk [†]	Risk for receiving A-B mismatched transfusion (%)
DSH	134	119 (88.8)	15 (11.2)	0	0.335	0.099	19.8
Males	50	45 (90.0)	5 (10.0)	0	0.316	0.090	18.0
Females	84	74 (88.1)	10 (11.9)	0	0.345	0.105	21.0
DLH	128	112 (87.5)	15 (11.7)	1 (0.8)	0.342	0.103	20.6
Males	68	56 (82.3)	11 (16.2)	1 (1.5)	0.402	0.136	27.2
Females	60	56 (93.3)	4 (6.7)	0	0.259	0.063	12.6
Total	262	231 (88.2)	30 (11.4)	1 (0.4)	0.338	0.101	20.2

* B allele frequency was calculated assuming Hardy-Weinberg equilibrium and not including the type-AB cats; q^2 is the proportion of type B cats.

† Proportion of matings at risk = $(p^2)(q^2) + 2pq(q^2)$, where q^2 = proportion of type B, q = frequency of b allele, p = frequency of a allele, and $p = 1 - q^2$.