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Blood transfusion in animals: A review

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Abstract

Blood transfusion is a method wherein one animal (recipient) receives with great caution the blood products (whole blood or part of blood) from another animal (donor) of the same species. For blood transfusion, it is important to know the blood volume and blood groups of each animal. The review gives an updated overview to the reader regarding the history, blood volume, blood group of animals and the process of blood transfusion in animals. The occurrence of various blood grouping systems in animals is of much concern to modern transfusion medicine. Blood banks could help to ease the process of transfusion of blood. We look into the future for enhanced ways to approach animals that needs a blood transfusion.

Keywords: blood volume, blood bank, blood groups, blood transfusion

Introduction

Blood transfusion has been successfully used since the 20th century to save the life of animals, which were in the stage of severe anemia and hemorrhage. It involves the transfer of blood consisting of plasma, red blood cells, white blood cells and platelets. Experts in veterinary field have done blood transfusion in various animals, and also contributed a lot to transfusion medicine. They have even hinted the possibility of separating the whole blood into its fraction for most efficient use. The ability to separate the blood into fractions (Apheresis) has helped improve the storage period and to specifically use the blood constituents depending on the requisite. Advanced screening facilities, testing blood groups, cross-matching of blood had made the process accurate. Due to the several antigenic combinations in blood groups of animals, probably there may not be any universal donors in animals. Although there are plenty of advantages of blood transfusion, it still poses several risk factors that need to be studied. The rapid advancement of Blood Transfusion in veterinary practice (especially with small animals) has interested us in writing this review as it would be of practical help to many budding veterinarians.

Brief history of development of blood transfusion

Table 1: Brief History of Blood Transfusion

Year	Scientist	Contribution	Remarks
1628	William Harvey	Proposed the theory of blood circulation	
1665	Richard Lower	First to study canine blood groups, and conduct blood transfusions between canines. He exsanguinated the dog fully and conducted blood transfusion successfully	c.f. Choudhary <i>et al</i> , 2017
1667	Richard Lower and Prosper Denis	Transfusion between heterologous species like lamb and humans	Had a very bad outcome
1667	Prosper Denis	Performed the first animal-to-human transfusions in the year 1667	Transfused lamb blood to a 5-year old child, who suffered from severe illness
1829	James Blundell	Successfully rescued a 25-year-old woman who had suffered from postpartum hemorrhage by doing blood transfusion at right time	
1900	Karl Landsteiner	Discovered the blood group in humans	This laid the foundation of cross matching before transfusion
1907	Reuben Ottenberg	Cautioned about the blood donor and the transfusion	
1914 to 1918		Various anticoagulants like sodium citrate were established	
2007		Successful blood bank established in the United Kingdom	
2018		First Blood bank for Dogs established Blood4Pet Mobile App developed	TANUVAS, Chennai
2020		Blood bank established	GADVASU, Ludhiana

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Indications

The various components of blood can be used in different conditions as indicated below:

Fresh Whole Blood

Fresh Whole Blood that is less than 8 hours old and has not been refrigerated and has all cellular and fluid components of blood. Stored Whole Blood is blood that is more than 8 hrs old. It can be stored at 33.8-42.8 °F (1 - 6 °C) for a maximum of 28-35 days.

- Treatment for anemia with thrombopathy or severe thrombocytopenia and disseminated intravascular coagulation
- Animals with severe trauma requiring massive transfusion
- Animals suffering from blood-related protozoal diseases like Anaplasmosis, Babesiosis
- Animals suffering from anaemia with hypoproteinemia
- For intravascular volume expansion and oxygen support

Packed RBCs

Contains concentrated RBCs with a PCV of 80 percent. Depending on the anticoagulant used, it can be stored for 28 – 35 days.

- Animals with symptomatic anemia including anemia due to hemorrhage, hemolysis, renal disease and decreased production of RBCs (bone marrow suppression)
- Helps to increase RBC concentration in animals that require oxygen support

Platelet Rich Plasma (Platelet concentrate)

Obtained by centrifuging fresh blood at a rate slower than that used for production of packed cell volume and plasma. Difficult to store. Can be used within 48 hrs if kept away from light at room temperature. Should not be refrigerated.

- Consistently administered to animals with life-threatening hemorrhage due to marked thrombocytopenia
- To animals with hemorrhage secondary to congenital or acquired thrombopathy

Fresh Frozen Plasma

Can be stored at -4 to -22 °F (-20 to -30 °C) for a period of 1 year without harming the coagulation factors. Thaw the plasma carefully to 98.6 °F (37 °C) before use.

- For treating burns.
- In cases of anticoagulant rodenticide intoxication.
- It is used in coagulopathy due to factors II, VII, IX, X, XI, X, fibrinogen and anti-thrombin III.

Cryoprecipitate

Cryoprecipitate is the cold, insoluble portion of plasma that precipitates after Fresh Frozen Plasma has been thawed slowly in the refrigerator at 33.8 to 42.8 °F (1 – 6 °C). It has a slushy consistency^[7]. It can be stored at -4 to -22 °F (-20 to -30 °C).

- Used in the treatment of Hemophilia A (factor VIII deficiency), Von Willebrand Disease and hypofibrinogenemia (as it contains von Willebrand Factor, factor VIII and fibrinogen).

Blood and Blood Volumes of Animals

Blood is the vascular connective tissue composed of fluid parts termed plasma and of corpuscles viz - erythrocytes or red blood cells, leucocytes or white blood cells and platelets.

The shape and size of red blood cells vary in different animals eg. Dog's RBC is a typical biconcave disk, whereas the Goat's RBC is more spherical. RBC shape in Camel is elliptical, in Deer it is sickle shaped. Humans and animals have blood volumes of 7% to 9% of their body weight. When there is a reduction in the blood volume, transfusion is generally required.

Table 2: Blood volume in various animals^[9]

Animals	Blood volume (ml/ kg)	Average body wt (kg)	Total Blood Volume (ml)
Cattle	55	300	16500
Goat	66	20	1320
Sheep	66	35	2310
Dog	86	25	2150
Cat	55	5	275
Pig	65	60	3900
Horse	76	450	34200
Monkey (Rhesus)	54	8	432
Rabbit	56	4	224
Guinea pig	75	1.2	90
Ferret	75	2	150

Blood Types

Every species has specific cell surface antigens on its RBC which differ leading to the development of the blood groups in animals. In animals, there is a combination of blood factors leading to the terminology of Blood grouping system rather than blood groups.

Table 3: Blood groups of animals^[14]

Species	No. of blood group	Description	References
Cattle	11	A,B,C,F,J,L,M,R,S,T,Z	
Sheep	7	A,B,C,D,M,R,X	
Goat	5	A,B,C,M,J	
Horse	8	A,C,D,K,P,Q,U,T	
Pig	11	A-O,C,F,G,H,I,J,K,L,N,O	[8]
	15		
Dog	9	DEA1.1,1.2,3,4,5,6,7,8, Dal antigen	[1]
Cat	4	A,B,AB, Mik antigen	[17]
Chicken	13	A,B,C,D,E,H,I,J,K,L,N,P,R	[2]

Blood groups are produced by the presence of species-specific antigens on the cell membrane of red blood cells. These factors cause a devastating role in causing adverse-systemic reactions following transfusion. Antigens can also get adsorbed onto the leucocytes, platelets, and plasma protein failing transfusion. When these antigens encounter other organisms either by transfusion or through transplacental exposure, it induces the production of antibodies in the young ones and even causes neonatal isoerythrolysis in certain species like dog^[15].

General Principles of Blood Group Testing

Blood Typing

It is a technique by which the surface antigen of the erythrocytes can be identified. It works well to screen the blood donors of the animals before crossmatching and transfusion. They are determined in the laboratory and even blood-typing kits like card-based agglutination assay, immunochromatographic cartridge and gel column diffuse assay are available in the market. These cards are available for both felines and canine's blood- typing and can detect

DEA 1.1 and felines type A, B, and AB. In samples of canine blood that is potentially DEA 1.1 – negative, the laboratory can also type the blood or DEA 1.2 to confirm that RBCs are negative for both DEA 1 alleles which could mean that dog is a Universal donor [7].

Crossmatch

The procedure directly involves the reaction of the donor's blood in the recipient. It is similar to blood typing, except those specific antisera are not used. The major crossmatching uses the crossmatching of donor's erythrocyte with recipient serum, whereas, the minor matching is just the reverse. The end reaction to being noticed is hemolysis and agglutination. There are several in-house cross-matching tests like Alvedia, Rapid Vet H Major for both feline and canine species. Since cats possess antigens against the blood type they lack, mismatching is more common and often fatal. Therefore, cross matching must be done in cats for every successful transfusion.

Selection of Donor

- The blood donors need to be blood grouped.

- They must be healthy and should be free from any infection.
- Animals should not be on any medication.
- Previous clinical history of the animal should be considered and they must possess normal levels of PCV (35 - 40% depending upon the species) and total protein concentration before transfusion.
- Dogs should be tested for von Willebrand factor.
- Body weight, temperament and vaccination reports must be recorded (vaccine especially in Dogs and cats should be up to date).
- After evaluating the above parameters the blood should be collected aseptically by jugular venipuncture.

Table 4: Quantity of blood that can be collected from the animal [10]

Species	Amount of blood to be collected (ml per kg Bd. Wt.)
Dog	15
Cats	10 to 12
Cattle and Sheep	8 to 14
Horses	6 to 8 litres

Table 5: Blood Collection details in Dogs and Cats [7]

Species	Volume of blood that can be donated	Frequency of donation	Needle gauge (G)	System of Blood collection
Dog	10%	4 times per year (can donate every 4-5 weeks if needed)	16	Closed
Cats	60 ml at a time		19-21	Open

Anticoagulants used for blood transfusion

Citrate-phosphate-dextrose-adenine (CPDA-1) and Acid-citrate-dextrose (ACD) are the anticoagulants used for preserving blood for transfusion purpose. Using CPDA-1 blood can be stored for almost 35 days, as it can maintain a higher concentration of 2, 3 diphosphoglycerate and adenosine triphosphate. ACD treated blood can be stored for 21 days. Heparin is not much effectively used as it activates the platelets [10].

Procedure of blood transfusion

Farm animals

- The blood transfusion kit consists of a blood collection bag having a capacity of 2 liters with an anticoagulant.
- Anticoagulants like Sodium citrate (100ml/L of blood), Acid citrate dextrose (50ml/450ml of blood) can be used in preserving blood [18].
- Cattles can donate blood up to 1.6% of its body weight [11].
- Once everything is prepared, Blood can be collected from the donor by jugular venipuncture. Collect blood with anticoagulants and slowly shake it.
- Transfusion should be done carefully by noticing the adverse reaction even though the effect is less during the first transfusion.
- The transfusion reactions include increased respiratory rate, tachycardia, sweating, violent movements.
- It is advised to transfer the blood into the recipient gradually for the first 30 minutes. Importantly, the process should not exceed more than 4 hours.
- Do not administer calcium or hypotonic fluids immediately after blood transfusion, as it may lead to hemolysis.

Dogs and Cats

- Identify the transfusion recipient.
- Blood transfusion can commence after Typing / Cross-

- match of blood is done.
- Collect blood aseptically from the jugular vein.
- Dogs can safely donate 15-20ml/kg, whereas cats can donate 10-12ml/kg body weight.
- Blood should be collected into sealed, gas diffusible blood bags with the use of an anticoagulant (CPDA-1 at a ratio of 1 ml of anticoagulant per 9ml of blood).
- The amount transfused to the animal is calculated based on the bodyweight and Packed Cell Volume.
- Precautions to be followed
 - Warm the unit of blood to be administered, to body temperature
 - Suitable IV catheter should be used to render RBCs undamaged. To prime the link, a non-heparinised saline is used.
 - Blood filter is commonly used to remove clots, that may have formed during the collection and storage process. From the fluid pump, extension lines are placed to comfortably reach the patients and are attached to the part on the IV catheter.
 - Initial stages of transfusion should be done slowly to monitor for an acute reaction
 - Vital signs should be checked every 15 minutes during the first hour and every 30 to 60 minutes thereafter.
 - All transfusions should be administered within 4 hours to prevent the risk of contamination.
 - After completion, a post-transfusion PCV is performed to assess the patient

Methods of Blood collection

- Open system: It refers to the system where the microbial-free environment is not guaranteed and so the shelf life of blood is spontaneously reduced. It is preferred in cats since only a small amount of blood is generally transfused and can be collected by syringe.
- Closed system: In this system, the sterility of the blood is maintained. This is suitable for processing and storage of

blood and blood products. It holds well in case of canines.

Dogs can donate blood every 4 weeks, whereas cats can possibly donate every 8 weeks. Dogs and cats can donate blood after 11 days of vaccination ^[10].

Wild animals

Thengchaisri ^[13] stated that the Bengal tigers possess predominantly Type A blood groups. It was reported in the Independent newspaper (2018) about Indian Veterinarians who carried out rare blood group transfusions in an attempt to save a seven-month-old tiger that had been attacked by the villagers in Central India. Cases have also come to light about Elephant blood transfusion by wildlife veterinarians of South Africa in the year 2018. Evidence of blood transfusion in Primates are also available ^[6].

Blood Banks

The demand for animal blood, is fast-growing through the years as there is increased pet adoption. Blood banks

- a. Help to ease the usage of blood in the recipients and also avoids several cross-reaction
- b. It provides convenient access to blood and also relieves the suffering of the animals
- c. It gives immediate action in finding a correct match for the animal without any further delay

The enormous advancement in the veterinary field has seen researchers developing blood banks for pets. The first canine to canine blood transfusion was done as early as the year 1665. Since then whole blood and blood products have been used to treat many diseases and also for surgery in veterinary medicine. In the year 2007, a successful blood bank was established in the United Kingdom. In India also, it has gained importance at the local, regional and national levels due to the need for blood during various emergencies. India's first blood bank for dogs was started by the Tamil Nadu University of Veterinary and Animal Sciences (TANUVAS). They further developed a mobile app called Blood4Pet with the aim of providing continuous blood to the needy pets ^[12]. This app can connect the client with the resource person and significantly contributes to saving the life of the needy pet at an economical cost. Another blood bank was initiated by the Guru Angad Dev Veterinary and Animal Sciences University (GADVASU) in Ludhiana in 2020.

Certain drawbacks

An adverse effect of transfusion or transfusion reaction (which may be acute or delayed) consists of the range of immunologic and metabolic changes that occur during or after the administration of a blood product. However, acute hemolysis is limited in domestic animals.

Dogs atypically have clinically significant preformed antibodies, and so those that have received frequent transfusion are at higher risk. Another most common hemolytic reaction in dogs is delayed hemolysis, wherein it is exhibited clinically as decreased survivability of transfused RBCs ^[10]. Crossmatch - compatible RBC given to horses and cattle survive only for 2 to 4 days ^[16]. Besides, hemolysis can occur due to improper collection, overheating of RBCs, insufficient storage, and also by forcing the blood through a small needle ^[4]. Transfused blood products may outwardly cause urticaria, fever, vomiting due to sepsis, hypocalcemia from citrate ^[10].

Future Prospects

- As the science of medicine flourishes, there will be improved technology and labs for doing more research works like extending the shelf-life of stored blood.
- Blood-borne disease transmission would be controlled by proper screening facilities like platform typing in animals. Raising of more blood banks in the coming years will alleviate the sufferings of many needy animals and can tackle blood transfusion efficiently.
- Novel methods such as cell salvage in surgical patients, autologous transfusion and xenotransfusion need to be developed for further success in this field.

Conclusion

Transfusion medicine provides an emergency and life-saving modality in critically ill animals which have inadequate quantity of blood. Although there is a lot of risk factors involved in transfusion, we still have to go for it to save an animal. To avert the undesirable reaction, the donor's blood must be properly screened and processed with adequate knowledge. Besides, the blood transfusion should be guided with care till the process gets completed.

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