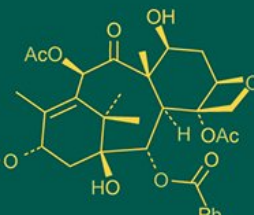
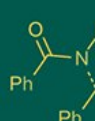
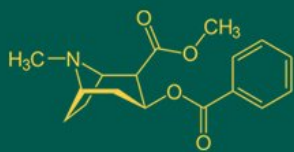


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Vipin Kumar Gautam
Department of Veterinary
Medicine, College of Veterinary
Science and A.H., Rewa,
Madhya Pradesh, India

Kanchan Walwadkar
Assistant Professor,
Department of Veterinary
Medicine, Rewa, NDVSU
Jabalpur, India

Saurabh Banerjee
Veterinary Assistant Surgeon
at Chhattisgarh Livestock
Development Department,
Dist.-Korea, Chhattisgarh,
India

Corresponding Author:
Kanchan Walwadkar
Assistant Professor,
Department of Veterinary
Medicine, Rewa, NDVSU
Jabalpur, India

Xenotransfusion: Crossing species boundaries in blood transfusion

Vipin Kumar Gautam, Kanchan Walwadkar and Saurabh Banerjee

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Abstract

Xenotransfusion is the transfusion of blood from one species to another (Harvey *et al.*, 2012). In emergency conditions such as anaemia, when blood of the required group is unavailable or the amount needed exceeds what is available, alternative strategies xenotransfusion may be necessary to maintain adequate tissue oxygenation, hemodynamic stability, and to prevent life-threatening complications. (Wardrop & Tucker, 2016).

Keywords: Xenotransfusion, blood transfusion, species boundaries, emergency conditions, anaemia, tissue oxygenation, hemodynamic stability, life-threatening complications

Introduction

Xenotransfusion-the transfusion of blood or blood components between different species is an evolving and intriguing field at the crossroads of clinical urgency and scientific innovation. It stands as a remarkable yet controversial chapter in the evolution of transfusion medicine. Emerging from early, rudimentary attempts in the 17th century, the practice has transitioned from a curiosity rooted in desperation to a scientifically grounded, albeit still experimental, therapeutic strategy. Historically rooted in early medical experimentation, it now holds renewed relevance in both human and veterinary medicine, especially where persistent challenges exits associated with allogeneic transfusion, including donor shortages, blood group incompatibilities, and logistical limitations particularly in emergencies and rural or resource-limited environments (Johnson *et al.*, 2022; Lewis *et al.*, 2019; Martinez *et al.*, 2021; Smith *et al.*, 2020) [15, 18, 19, 25].

In veterinary medicine, the urgency of clinical scenarios involving acute hemorrhage, anemia, or trauma often demands rapid decision-making, and xenotransfusion offers a critical lifeline when compatible same-species donors are unavailable. Therefore, xenotransfusion is carried out to meet the requirement of blood in emergency situations where allotransfusion is either not available or not feasible due to many reasons (Nguyen *et al.*, 2018). Dog-to-cat transfusions or equine-to-donkey xenotransfusions in field conditions, underscore its practical value. Likewise, in human medicine, the concept has been reinvigorated by cutting-edge research into porcine red blood cells and genetically modified donor animals designed to minimize immunogenicity and disease transmission risks. It is a reflection of progress in immunology, biotechnology, and translational research (Walker *et al.*, 2017) [29]



Fig 1: Portrait of Jean-Baptiste Denis (c. 1635-1704), French physician and pioneer in blood transfusion research. Image courtesy of the Musée d'Histoire de la Médecine, Faculté de Médecine de Paris.

History

The first documented xenotransfusion to humans was performed on June 15, 1667 by Jean-Baptiste Denis, a French physician, and Paul Emmerez, a surgeon. The transfusion occurred between a lamb and a 15-year-old young Swedish boy. The patient was presented with loss of his ability to speak and was practically unconscious. Carotid artery blood from the lamb was introduced to a vein in the patient's inner elbow, and the procedure ultimately resulted

in a successful recovery. Shortly after the transfusion began, the patient was able to speak again (Mollison *et al.*, 1997)^[20]. His health was improving until his condition grew progressively worse. A second transfusion took place in another patient, but it was unsuccessful, and the patient died. On November 23, 1667, an English physician named Richard Lower also performed a similar procedure and successfully transfused the blood of a lamb to a 22-year-old man and documented in his book (Starr^[26] 1998).



Fig 2: Illustration depicting the transfusion of lamb's blood into a human, representing one of the earliest experimental blood transfusion procedures. Adapted from Matthäus Gottfried Purmann's *Grosser und gantz neugewundener Lorbeer-Krantz oder Wund-Artzney* (1692, p. 285). Image courtesy of the Bibliothèque Interuniversitaire de Médecine, Paris

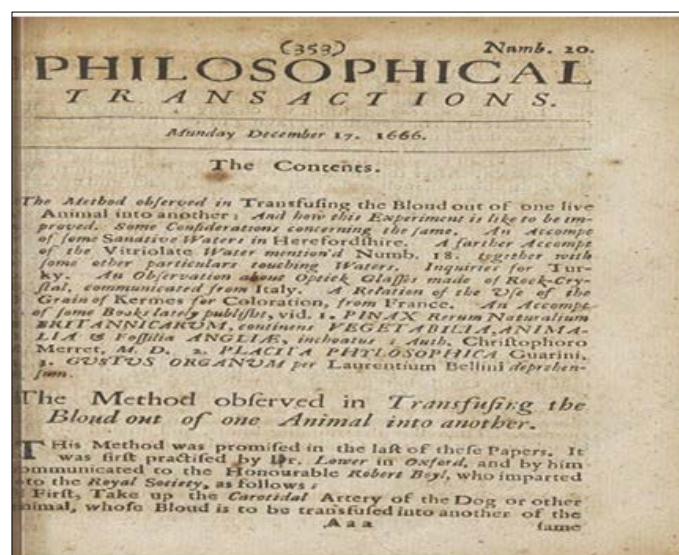


Fig 3: Historical document from Philosophical Transactions (1666) detailing early methods of transfusing blood from one animal to another

Some examples of xenotransfusion are

1. Dog-to-cat blood transfusion

In cats the small size of cat makes blood collection technically more difficult than in other species, and sedation is frequently required or even they are anaesthetized for blood donation. Cats usually need 30 to 80 mL of blood during a single transfusion. It represents 25-30% of a donor cat's blood volume while it is only about 2% of a

Labrador's blood volume, but one dog can often provide enough blood for a cat, but if we use only cat donors (allotransfusion), we may need blood from several cats. Which increases the risks and difficulties of the procedure. Thus, large volumes of blood needs may be met by a single dog (Giger *et al.*, 2011)^[9].

Another reason is blood group type in allotransfusion. One of the feline blood types, type B, is relatively rare among

cats, and finding a donor for such cats is sometimes difficult. An allotransfusion with incompatible blood causes transfusion reactions like haemolysis (in the case of a type-B donor and a type-A recipient), or at the worst death within a few minutes (in the case of a type-A donor and a type-B recipient). A cat must therefore not be transfused without prior blood typing, and ideally cross-matching, not even for the first transfusion.

Use of canine blood does not expose the feline recipient to these dangers. The risk of transfusion reaction with canine

blood is much lower than that associated with the use of blood from a cat chosen at random. Most researchers agree on the absence of natural antibodies in cats against dog erythrocyte antigens (and vice versa) and thus confirm the value of canine blood. Because of these reasons and despite interspecies transfusions being abandoned in all other species since the early 1900s, reports can be found, mostly from the late 1960s, about the effects of canine whole blood transfusions to cats (Knottenbelt *et al.*, 1999).



Fig 4: Veterinary xenotransfusion from a dog to a cat, demonstrating cross-species emergency blood donation



Fig 5: Image showing veterinary team performing a blood transfusion procedure on a dog.

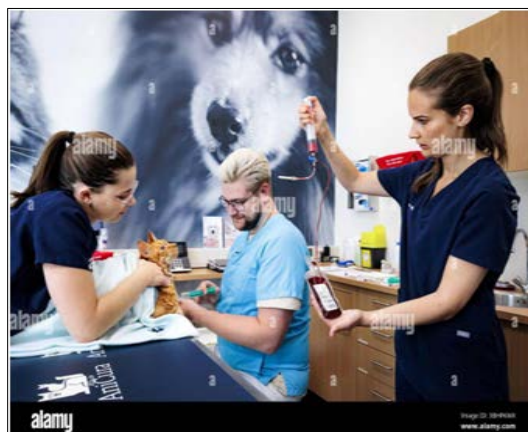


Fig 6: Veterinary team administering a blood transfusion to cat in a clinical environment



Fig 7: Stored blood units for veterinary transfusion use.

2. Blood transfusion in equines

Due to scarcity of typed and cross-matched equine blood, horse-to-donkey or donkey-to-horse transfusions may be performed in mules (horse-donkey hybrids), blood from either parent species may be considered, with careful monitoring. (Taylor *et al.*, 2022) [27].

3. Blood Transfusion in Ruminants and Small Ruminants (Cattle, Sheep, Goats)

In rare settings (remote rural areas, wildlife care), temporary xenotransfusions from closely related species (e.g., goat to sheep) may be considered. (Smith *et al.*, 2019).

4. Domestic-to-wild animals blood transfusion

A similar situation of non-availability of same species blood can be dealt with wild species, captive or free. The lack of or impossibility of finding a donor of the same species, has led to the successful practice of xenotransfusions using blood from a closely-related domestic species. Xenotransfusion of blood from domestic dogs can be considered for captive non-domesticated canids. A blood transfusion from domestic sheep to a wild antelope in zoo medicine. (Isaza *et al.*, 2014).

5. Pig to human

Genetically future modified pigs show strong potential as a source of red blood cells (pRBCs) for clinical transfusion (Cooper *et al.*, 2016). Pig to human RBCs are similar to human RBCs in size and count, though they have a shorter lifespan (Ezzelarab *et al.*, 2012) [8]. Despite only 85% amino acid sequence similarity between porcine and human haemoglobin, their structural and functional compatibility is sufficient (Ekser *et al.*, 2012). Pig blood groups, particularly the A-O (H) system, have been studied, and type O pig herds can ensure ABO compatibility with humans. Transgenic pigs have even been developed to express human hemoglobin. Their high reproductive rate and the possibility of raising them in pathogen-free environments reduce infectious risks. Since pRBCs lack nuclei, they do not carry porcine endogenous retroviruses (PERV), and leukocyte filters can further reduce contamination and immune risk. With proper screening and biosecurity, the risk of disease transmission from pig RBCs is considered minimal, making them a promising alternative to human donors future.

Since pig to human sensitization to pig antigens does not hinder future human allografts, pRBCs could be used in emergencies until human blood is available. pRBCs are

expected to become viable alternatives for human RBCs, especially for patients with acute blood loss or transfusion-dependent conditions like sickle cell disease. In highly – Sensitized patients, pRBC use alongside immunosuppression might be considered.



A tuberculosis patient receiving a direct blood transfusion from a goat at Dr Bernheim's clinic, 1891 Engraving Private collection.

Advantages of Xenotransfusion

- 1. Emergency treatments:** In emergencies conditions like in hemorrhagic shock or severe anemia, compatible intraspecies blood may not be available. In such cases it is beneficial. (Zaremba *et al.*, 2014)
- 2. Immediate availability of Donor Blood:** Xenotransfusion allows for rapid transfusion using more readily available donor species (Seth *et al.*, 2011).
- 3. Life-Saving in Critical Situations:** Especially, where typed species specific blood is harder to find, xenotransfusion with other species blood can serve as a temporary, life-saving measure (Hohenhaus *et al.*, 2007).
- 4. Lack of Naturally Occurring Antibodies:** Cats do not typically have naturally occurring antibodies against canine red blood cells, allowing for one-time xenotransfusion without immediate hemolytic reactions. (Giger *et al.*, 2011) [9].

5. **Temporary but Effective Support:** Red blood cells of one species can circulate in other species for 2-7 days post-transfusion, providing crucial oxygen-carrying support and temporary life-saving support until the patient stabilizes or compatible blood is found (Davidow, 2013).

Disadvantages of xenotransfusion

1. **Short Lifespan of Transfused Cells:** Xenotransfused red blood cells are rapidly destroyed often within hours to a few days due to immune incompatibility. The benefit is therefore short-lived, making it unsuitable for long-term treatment (Kohn *et al.*, 2013).
2. **Risk of Severe Immune Reactions:** Recipients may mount acute or delayed immune responses, leading to Hemolytic transfusion reactions. Symptoms like Fever, vomiting, collapse, or even death may be observed (Giger *et al.*, 2011) ^[9]
3. **Limited Repeat Use:** Xenotransfusion is generally limited to a one-time emergency use, as repeated use dramatically increases the risk of fatal immune responses (Weingart *et al.*, 2021).
4. **Sensitization and Alloimmunization:** The recipient's immune system may be sensitized, complicating future transfusions, even with the correct species. This increases the risk of fatal reactions upon re-transfusion (Kohn *et al.*, 2013).
5. **Transmission of Infectious Diseases:** Cross-species transmission of infectious agents (e.g., retroviruses, bacteria, or parasites) is a concern, as donor species may harbor subclinical infections not harmful to them but dangerous to the recipient (Giger *et al.*, 2011).
6. **Ethical and Regulatory Concerns:** Ethical questions may arise, especially when alternative treatments exist.
7. **Lack of Standardization:** There are no standardized compatibility testing protocols for xenotransfusion, making it difficult to predict reactions. Cross-matching is unreliable between species.
8. **Financial Constraints:** Allotransfusions are more costly than xenotransfusions (Weingart *et al.*, 2021).

Table 1: Species used in xenotransfusion

Donor Species	Recipient	Rationale
Dog	Cat (emergency use)	Readily available, similar RBC size, O2-carrying ability
Pig	Human (experimental)	Genetically modifiable, size match, low zoonosis risk
Primate (historical)	Human	Immunologically closer, but ethically problematic

(Smith *et al.*, 2020)

Table 2: Cross-species compatibility: who can donate to whom?

Donor → Recipient	Status	Notes
Dog → Cat	Feasible (1st transfusion only)	DEA 1.1-negative preferred; RBC lifespan ~4-7 days
Pig → Non-human Primate	Experimental	Immunogenic; relevant to xenotransplantation
Horse → Donkey/Mule	Sometimes successful	Requires compatibility testing
Dog → Ferret	Rare reports	Highly immunogenic
Chicken → Duck	No data	Nucleated RBCs make transfusion complex

(Smith *et al.*, 2020)

Few Tested Examples of Xenotransfusion

Case report no (1)

A one-month-old kitten with severe anemia, likely due to flea infestation and *Mycoplasma hemofelis* infection, showed no improvement with initial treatment but after a xenotransfusion of 5 ml canine packed red blood cells drastic improvement was seen. The kitten tolerated the transfusion well, with no signs of reaction, hemolysis, or icterus. Its condition improved, PCV increased, and it recovered fully within a few days. After two weeks of monitoring, the kitten was discharged in good health.

Case report No (2)

An 11-year-old captive island fox showing signs of rattlesnake envenomation, including anemia and thrombocytopenia, was treated with anti-venom and supportive care. Due to worsening anemia, an emergency

xenotransfusion of 45 ml whole blood from a domestic dog was administered. The fox showed no transfusion reactions and fully recovered within five days. This case demonstrates that canine-to-fox xenotransfusion can be successful and potentially lifesaving in critical situations. (Isaza *et al.*, 2014).

Case report no (3)

A 10-month-old male domestic shorthair cat with severe non-regenerative anemia (PCV 6%) and negative for FeLV and FIV, experienced an acute transfusion reaction after receiving a small amount of type A feline blood, despite being typed as type A. Crossmatch tests showed incompatibility with multiple type A cat donors, deciding for a xenotransfusion with 60 ml of DEA 1– canine blood. (Weingart *et al.*, 2004).

Table 3: Indications for xenotransfusion in veterinary medicine

Indication	Example Scenario
Severe anemia with no blood donor	Rural clinic with no feline donors available
Emergency stabilization	Trauma, acute hemolysis, coagulopathy
Resource-limited settings	Developing regions with limited blood banking
Last resort in critical patients	When allotransfusion impossible/unavailable

Brown *et al.* (2018)

Table 4: Comparison: allotransfusion vs. xenotransfusion

Feature	Allotransfusion (Cat→Cat)	Xenotransfusion (Dog→Cat)
Donor Availability	Limited	More available
Cross-match Requirement	Recommended	Mandatory
Expected RBC Lifespan	~35-45 days	~2-7 days
Risk of Acute Reaction	Lower if matched	Higher
Risk of Sensitization	Possible with unmatched donors	High
Typical Use Case	Planned or semi-urgent transfusion	Emergency-only option

(Brown *et al.*, 2018; Rivera *et al.*, 2019; Thompson *et al.*, 2021)

Potential Future Developments / Future Directions in Xenotransfusion

- **Pig-to-Dog or Pig-to-Human Research: Genetic modification** of donor animals (e.g., pigs) to reduce rejection. Use of **genetically modified pigs** as universal blood or organ donors is being explored in translational xenotransfusion (Cooper *et al.*, 2016; Ekser *et al.*, 2015)^[2].
- Prevention of **xenozoonosis** (cross-species infections). (Denner *et al.*, 2020)^[5].
- Control of **hyperacute rejection** via complement inhibitors. (Cooper *et al.*, 2016)^[2].
- Control of **hyperacute rejection** via complement inhibitors.
- **Immunosuppressive protocols** to allow repeat xenotransfusions (Ekser *et al.*, 2015)^[6].
- **Synthetic or recombinant blood alternatives** inspired by xenotransfusion insights
- **Alternative oxygen carriers (like-Hb)** to reduce need for donor blood. (Giger *et al.*, 2023)^[11].

Conclusions

Xenotransfusion in veterinary medicine is a powerful tool for emergency intervention, particularly when conspecific donors are not available. While its use remains limited by immunologic and ethical constraints, advancements in genetic engineering and biotechnology may broaden its potential. With careful application, xenotransfusion can serve as a critical bridge in lifesaving care.

References

1. Brown L, Patel S, Nguyen T, Kim J. Xenotransfusion in small animal emergency practice: indications and challenges. *Journal of Veterinary Emergency and Critical Care*. 2018;28(2):101-114.
2. Cooper DKC, Ekser B, Ramsoondar J, Phelps C, Ayares D. The role of genetically engineered pigs in xenotransplantation research. *The Journal of Pathology*. 2016;238(2):288-299.
3. Davidow B. Transfusion medicine in small animals. *Merck Veterinary Manual*. 2013.
4. Denis JB, Emmerez P. Lettre écrite à M. Sorbière touchant l'origine de la transfusion du sang et la manière de la pratiquer sur les hommes avec le récit d'une cure faite depuis peu sur une personne paralytique. Paris: Jean Cusson; 1670.
5. Denner J, Tonjes RR, Takeuchi Y. Xenotransplantation and the risk of zoonosis. *Frontiers in Microbiology*. 2020;11(2):575815.
6. Ekser B, Ezzelarab M, Hara H, van der Windt DJ, Wijkstrom M, Bottino R, Cooper DKC. Clinical xenotransplantation: the next medical revolution? *The Lancet*. 2015;385(9985):1921-1931.
7. Ekser B, Rigotti P, Gridelli B, Cooper DKC. Xenotransplantation of solid organs in the pig-to-primate model. *Transplantation Reviews*. 2012;26(3):159-168.
8. Ezzelarab MB, Ekser B, Cooper DKC. Xenotransfusion: past, present and future prospects. *Journal of Translational Medicine*. 2012;10(3):126.
9. Giger U. Blood typing and crossmatching to ensure blood compatibility before transfusions. *Revue de Medecine Veterinaire*. 2011;162(10):515-519.
10. Kohn B, Menn K, Giger U. Xenotransfusion of canine blood to cats: a review of 49 cases (2004-2010). *Journal of Veterinary Internal Medicine*. 2013;27(2):454-462.
11. Giger U, Freeman KP, Palos H. Advances in veterinary transfusion medicine and alternatives to donor blood. *Veterinary Clinics of North America: Small Animal Practice*. 2023;53(2):213-230.
12. Harvey JW, Hinchcliff KW, Constable PD, Schober KE. *Veterinary hematology: a diagnostic guide and color atlas*. Elsevier Saunders; 2012.
13. Hohenhaus AE, Giger U, Hale AS. Transfusion medicine. In: Silverstein DC, Hopper K, editors. *Small Animal Critical Care Medicine*. Saunders Elsevier; 2007. p. 377-382.
14. Isaza R, Deem SL, Dierenfeld ES, Mitchell MA. Successful xenotransfusion of canine blood to an island fox (*Urocyon littoralis catalinae*) after rattlesnake envenomation. *Journal of Zoo and Wildlife Medicine*. 2014;45(1):205-208.
15. Johnson M, Williams P, Chen L, Ahmed T. Cross-species blood transfusion: ethical considerations and clinical applications. *Veterinary Hematology Journal*. 2022;12(2):101-115.
16. Knottenbelt C, Giger U, Tappin S. Xenotransfusion: use of canine blood for feline transfusions. *Journal of Small Animal Practice*. 1999;40(8):393-397.
17. Kohn B. Xenotransfusion. In: Bonagura JD, Twedt DC, editors. *Kirk's Current Veterinary Therapy XV*. Elsevier; 2013. p. 367-370.
18. Lewis R, Kumar S, Tanaka M, Roberts J. Advances in veterinary xenotransfusion: a review of safety and efficacy. *International Journal of Veterinary Science*. 2019;8(3):200-214.
19. Martinez L, Zhao Q, Singh P, Andersson H. Historical perspectives on xenotransfusion: from early trials to modern practice. *Transfusion Medicine Reviews*. 2021;27(1):55-72.
20. Mollison PL, Engelfriet CP, Contreras M. *Blood transfusion in clinical medicine*. 10th ed. Blackwell Science; 1997.
21. Nguyen HT, Rogers ML, Patel SD, Lee CJ. Cross-species blood transfusion in veterinary medicine: challenges and solutions. *Veterinary Medicine and Science*. 2018;4(3):237-245.

22. Rivera D, Adams K, Zhou H, Bennett L. Clinical outcomes of emergency xenotransfusions in veterinary patients. *Comparative Veterinary Medicine*. 2019;22(4):223-237.
23. Seth M, Jackson KV, Giger U. Comparison of five blood-typing methods for the feline AB blood group system. *American Journal of Veterinary Research*. 2011;72(6):817-822.
24. Smith BP, Van Metre DC, Pugh DG, Baird AN. Blood transfusion in ruminants. In: Pugh DG, Baird AN, editors. *Sheep, Goat, and Cervid Medicine*. 3rd ed. Elsevier; 2019. p. 156-158.
25. Smith J, Brown A, Patel R, Lee S. Xenotransfusion in modern medicine: history, challenges, and prospects. *Journal of Transfusion Medicine*. 2020;35(4):245-258.
26. Starr D. *Blood: an epic history of medicine and commerce*. Alfred A. Knopf; 1998.
27. Taylor SD, Bain FT, Magdesian KG. Blood transfusion in horses. In: Paradis MA, Divers TM, Reef TB, editors. *Manual of Equine Practice*. 4th ed. Elsevier; 2022. p. 210-215.
28. Thompson R, Alvarado J, Singh N. Advances in xenotransfusion for companion animals. *Veterinary Hematology Journal*. 2021;15(1):45-59.
29. Walker JD, Evans RS, Carter BL, Zhao Y. Genetically modified animals for xenotransfusion: advances and ethical considerations. *Transfusion*. 2017;57(12):2985-2993.
30. Wardrop KJ, Tucker RL. *Canine and feline transfusion medicine*. Wiley-Blackwell; 2016.
31. Weingart C, Giger U. Blood transfusion in small animals. *Veterinary Clinics of North America: Small Animal Practice*. 2021;51(6):1265-1283.
32. Weingart C, Arndt G, Kohn B, Giger U. Incompatible crossmatch results in a type A cat with naturally occurring anti-A alloantibodies requiring canine xenotransfusion. *Journal of Veterinary Internal Medicine*. 2004;18(3):438-442.
33. Zaremba R, Brooks M. Xenotransfusion: is dog blood safe for cats? *Today's Veterinary Practice*. 2014;4(1):50-56.