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Review Article

Xenotransplantation: Boon for Mankind

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Abstract
The advancement in genetic engineering has made xenotransplantation a viable transplant technology. Due to the acute need for donor organs, there is a significant push to advance the technology further; however, still technical challenges have to be met with. Xenotransplantation therefore needs extensive further research including clinical trials before pig donor organs could become an option for clinical care. With the technical development xenotransplant technology will become universal and more acceptable.

Keywords: Organ and tissue transplant; Risk factors; Genetic Engineering

Introduction
Generally, xenotransplantation means any cross-species transplantation for example, mouse to rat, pig to primate, and sheep to human, but in other animals, other than humans, it is for experimental purposes and to understand the intricacies behind xenotransplantation. There's a huge gap between organs needed and organ availability for organ transplant in humans. We approach filling the organ gap by xenotransplantation. Scientifically, in 1963 and 1964 experiments in transplanting chimpanzee kidneys into humans were conducted. Out of 13 kidney transplants from chimpanzees into humans, almost all of the transplanted organs failed within a few weeks, but one of the transplant recipients survived for nine months and was able to resume a normal life in good health until her sudden death [1]. But this idea was floating around long back when Lord Ganesha was born [2].

Year, 2022 has marked an important turning point for xenotransplantation, but many important hurdles remain yet to be solved. These include preventing transmission of endogenous viruses or other porcine diseases to the transplant recipient, as well as there is no immunological rejection even in long term.

Search for Suitable Animal as Organ Donor
Experimental Xenotransplant can actually be traced back to the early 1900'swhereseveral chimpanzee-to-human kidney transplants were attempted. Additionally, baboon-to-human kidney, heart, and liver transplants, were attempted. Pig organs are generally preferred because:

- Most pig organs are similar in size and functionally very similar to human.
- In terms of kidneys, the kidney function measures in pigs and humans are very similar.
- Pigs have a long-life expectancy (~30 years). Meaning there's hope that a pig-to-human transplant would be long-lived in the human recipient.
- Pigs reproduce relatively rapidly and have a large litter size providing the potential to produce a large supply of organs (e.g., pigs are a scalable species to produce donor organs).
- They can be raised in environments free from pathogens (e.g., viruses or bacteria that could potentially infect humans). This prevents the risk of transferring pig viruses into the recipient and
- Genetically modifiable to reduce the risk of immune rejection.:

Genetic Engineering
Only recently, the tools to extensively genetically engineer pigs to make the necessary changes were available due to the advancement in gene editing technology. Therefore, making genetically engineering pigs potentially suitable for xenotransplantation could be made available. Scientists engineered pigs to produce organs compatible with the human immune and blood clotting systems. They removed genes and introduced human genes in pigs that make the pig organs less pig-like to make them more human like.

Benefits and Risks
Xenotransplantation is the transplantation of viable cells, organs, or tissues between species. There are long waiting lists for donor organs, and the gap between organ demand and supply continues to increase Solutions for this shortage are being investigated through activities in different research areas, including xenotransplantation. Pigs are being used to fill the gap, since they have a long-life expectancy (~30 years). Meaning there's hope that a pig-to-human transplant would be long-lived in the human recipient. More so, pigs reproduce relatively rapidly and have a large litter size providing the potential to produce a large supply of organs. Scientific advances, particularly in genetic engineering of the pig, mean that xenotransplantation could potentially alleviate human organ shortages.

Preventing Organ Rejection Technology

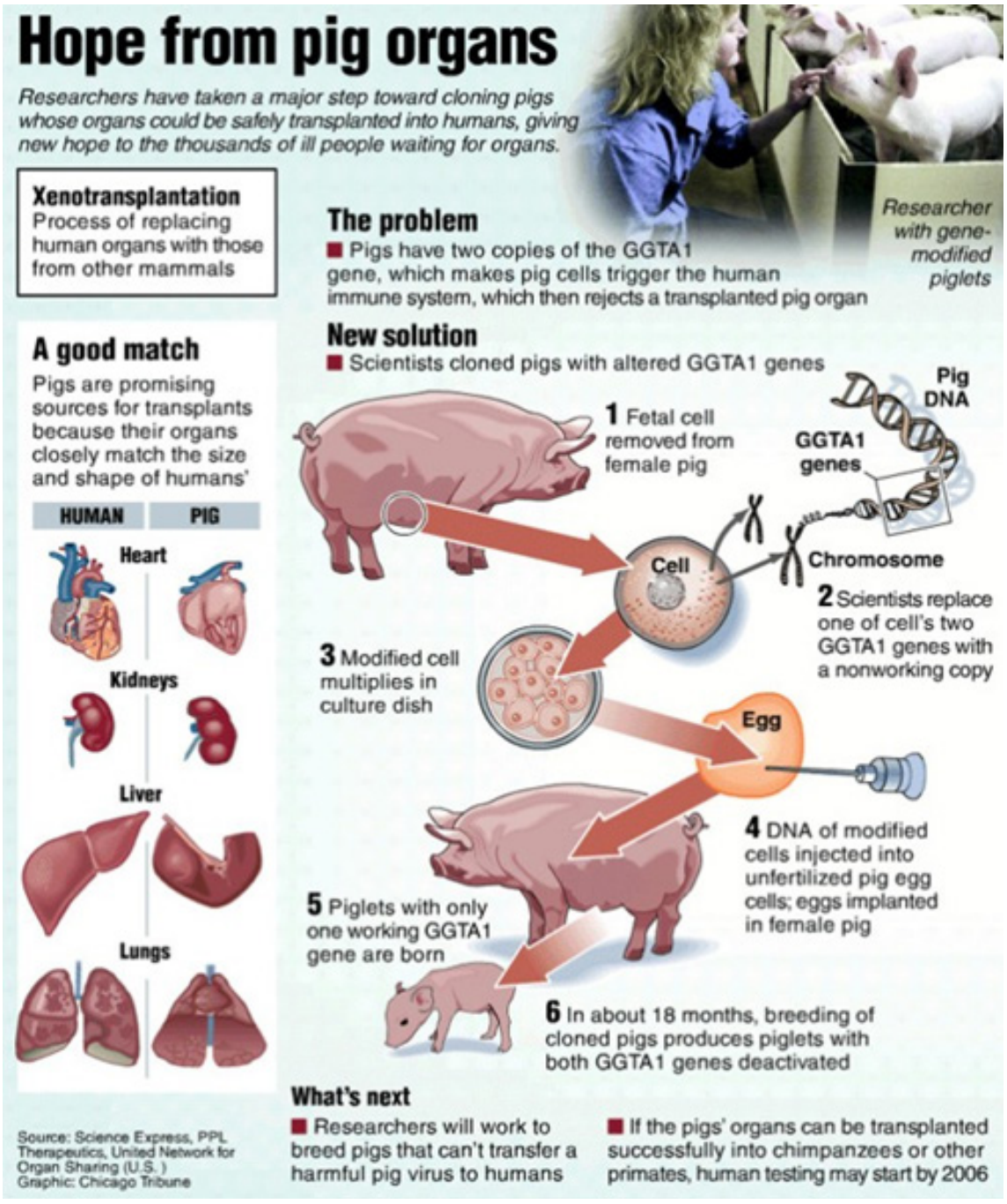
Traditionally in transplants of organs from one human to another cyclosporine a potent immune suppressant is used to suppress recipients' immune systems in order to allow transplanted organs to function without being attacked and rejected as foreign in xenotransplantation. The other technique was developed to overcome such organ rejection is the breeding of transgenic pigs. These genetically altered pigs express specific human proteins that make it more difficult for the human immune system to identify the porcine organ as belonging to a different species.

New cloning techniques may further enhance the immune-compatibility of pig organs by eliminating the pig gene-products that cause hyperacute rejection. In theory these developments should mean that once transplanted, animal organs could be treated in the same way as human organs, with the use of standard immunosuppressive regimens.

Managing infection risks

The transfer of an infectious agent from the animal to the human [3] is a serious concern in xenotransplantation; not only for the person receiving the organ, but also to those who come into contact with the recipient. Transmission of bacteria, fungi, and parasites can largely be prevented with improved animal husbandry practices. The donor animal should be properly vaccinated. Now potential pig colonies designated as 'pathogen free' are also raised. In addition, various laboratory test assays that can detect infection in pigs and humans exist, and that can detect pig infections in humans can also be done [4].

Graphical conclusions



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