EDITORIAL COMMENT

Practical ethical concerns in allocation of pig kidneys to humans

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ABSTRACT

The fundamental ethical question of whether pig organs should be transplanted into humans has been settled, as recent surgeries demonstrating proof of concept demonstrate. Other issues need to be considered and reconciled before xenotransplantation of pig kidneys becomes a solution to the organ shortage for people waiting for a kidney transplant or as a viable alternative to the deceased donor or living donor human kidneys. Human trials will be needed beyond brain-dead individuals to show that xenotransplantation is safe from immunologic and infectious standpoints. Transplant centers will need to show that xenotransplantation provides a long-term benefit to recipients and is financially viable. If trials are successful and receive regulatory approval, pig xenotransplants may become another option for people waiting for a kidney. Before patients are discharged with a functioning xenograft, practical issues with ethical implications remain.

Keywords: biocompatibility, clinical trial, elderly, immunology, kidney transplantation

INTRODUCTION

Recent surgeries at New York University (NYU) [1] and the University of Alabama Birmingham (UAB) [2] transplanting pig kidneys to brain-dead recipients demonstrate that issues of hyperacute rejection have been resolved and that the surgery is close to possible trials in living humans. The hope is that xenotransplantation of pig kidneys may help close the gap between patients listed for a kidney transplant and receiving one.

The shortage of human kidneys for transplantation is well known. A total of 78 690 people were listed and waiting for a kidney transplant in 2019, but only 25 539 deceased and living-donor kidney transplants were done that year in the USA [3]. People with kidney failure have dialysis as an option, yet all-cause mortality for dialysis patients was 156.6/1000 patient-years in 2019 compared with 46.8 for transplant patients [4]. A reliable supply of genetically modified pig kidneys could ease that shortage and give new life to people waiting on the list. Xenotransplantation could be in line with US government policy to reduce the number of people relying on dialysis and increase the number of transplants, although the executive order does not mention it as a specific option [5].

Researchers have made great strides in creating genetically modified pigs to prevent hyperacute rejection, activation of complement and hypercoagulability that needed to be addressed before pig xenotransplantation can become widespread. Immunologic issues like knocking out the gene for α-1,3-galactosyl transferase and inserting genes for human complement regulatory proteins and genes to prevent thrombotic microangiopathy and systemic consumptive coagulopathy have been resolved thanks to CRISPR/Cas 9 gene editing technology [6]. The UAB decedent recipient suffered an exsanguinating hemorrhage due to brain death physiology. More work on physiologic issues remains to understand how well the pig kidney will perform in the human
environment to maintain salt and water balance, electrolyte and acid–base homeostasis and renal bone metabolism. Questions also remain about whether human recipients will respond to porcine renin, erythropoietin and the effects of limiting the pig kidney response to human growth hormone.

Many ethical issues still need to be considered. They cut across several broad categories (Table 1) and touch on the basic concepts of human autonomy, equity, utility and social justice (Table 2). There is overlap and cross-over in the categories. The tables are examples of two ways to consider the issues and to identify potential stakeholders. Figure 1 illustrates the issues from proof of concept through clinical practice and by donor, organ and recipient.

The first category might be purely societal acceptance. How will different religious and racial groups view the use of pig kidneys in human beings? Will this be a barrier to offering kidneys to members of those groups? Will some hospital institutional review boards refuse to approve the transplants, limiting their accessibility? How will animal rights groups view xenotransplants? How will transplanter centers and potential patients balance the risks of xenotransplantation, like potential zoonotic infections, to patients and the broader society?

The second category is economic. How much will a xenotransplant program cost and will they only be available at certain centers? Will government and commercial insurers cover xenotransplantation? How will developers of the 10-genetically engineered (10-GE) pigs price organs and what is a fair return on their investment? Will cost make it impossible for people with public insurance or in areas with limited health care resources to receive pig kidney xenotransplants?

The third category is medical. How many pig kidneys would each recipient need to provide adequate clearance? What will the immunosuppression regimen be? How will other physiologic problems be resolved to ensure that the pig kidney performs adequately in all areas, not just small molecule clearance?

The fourth category is regulatory/legal. Who will have regulatory say over xenotransplantation? How will xenografts be allocated? How will medicine and regulators evaluate and how will society know how well pig kidney xenotransplant perform (will outcomes be tracked by the Scientific Registry of Transplant Recipients (SRTR))? How will patients be advised on balancing the benefit of getting a pig kidney against the potential risks of rejection and long-term zoonotic infection? Do others in the patient’s household need to be consented to accept infection risk? How will patients in trials be followed long-term, and may they withdraw from trials after transplantation?

The final category concerns the balance between social justice and utility. Who will participate in clinical trials and get pig kidney xenografts—people who need a kidney emergently because they have lost dialysis access, children with no potential living donors, patients with long wait times due to blood group or high degree of sensitization, patients who are too sick to wait for a human kidney? If outcomes are favorable, will xenografts only be available to those with the means to find a center that performs the surgery and pay for it? If outcomes are less favorable than with human kidneys, will xenografts be seen as a second-tier option? Will they be a bridge until a human kidney is available? Would they be available to people who are generally precluded from kidney transplant programs (prisoners, undocumented immigrants)?

This article has looked only at the question of pig kidney transplants in general. Porcine islet cell transplantation for type 1 diabetes, porcine heart transplantation and porcine corneal transplants share some of the same issues in general terms.
Porcine lung and liver xenotransplants are not as advanced but will also share common issues with kidney xenotransplants as they move closer to human trials.

**SOCIALE CONSIDERATIONS**

Discussion about the ethics of xenotransplantation from the 1990s and early 2000s evolved as the science advanced. Initial concerns centered on whether animal-to-human transplants violate the laws of nature and whether it is wrong to sacrifice animals as organ donors to humans. Some feared social injustice by lopsided distribution of scarce resources to a few at the expense of broader basic medical care for all. Critics wondered whether xenotransplantation would endanger public health [7].

Other pressing questions touched on prerequisites for clinical trials: identifying acceptable risk–benefit thresholds and clinically defining success (extra days versus extra weeks or months of life, for example). Some questioned whether informed consent should be obtained from close contacts of the patient and medical personnel involved in the recipient’s care, given concerns about zoonotic infection. It was argued that informed consent from recipients should include a broader set of risks including public attention, risk of transmitting disease and isolation. A final set of questions touched on who is responsible for oversight of clinical trials in xenotransplantation (local hospital review boards, national committees, or some combination)?

Ethicists and researchers considered the role of local institutional review boards (IRB) in approving xenotransplant clinical trials [8]. They argued that IRB members, particularly community members who may not have scientific or medical knowledge, would need ongoing education about xenotransplantation. They cited the model of the National Institutes of Health’s Recombinant DNA Advisory Committee, which focused initially on public fears about gene transfer but ultimately provided a public forum to discuss broader issues of gene transfer. IRBs would have to confront the inability of a subject to withdraw from a study once the xenotransplant had been made. In addition to ongoing training, the authors recommend that IRBs bring in non-voting consultants to help them reach a decision, as well as involve hospital ethics committees in an advisory role, particularly for the ethical concerns of the post-transplant period.

Scholars have looked at societal and religious attitudes toward xenotransplantation, convening focus groups of local religious leaders, organ procurement organizations’ staff, patients who need or have already received a transplant and local members of the business community [9]. Participants expressed concern about the ethics of using animals and the stigma of pigs in some religions. While many participants expressed ethical concerns, they didn’t see them as a roadblock, particularly if the heart and islet cells from the pig kidney donor could be used for other recipients. Imams and rabbis argued that the need to honor human life would take precedence over religious prohibitions against eating pork. Some participants worried about stigma for the recipient, particularly children, as well as isolation if infection risk required them to stay away from other people. Transplant administrators wondered whether insurers would pay for a pig kidney in someone who was too sick for a human kidney. Some participants questioned whether children should be given priority, while others worried about creating a two-tier system of who gets pig kidneys and whether pig and human kidneys are allocated differently.

In a theological symposium on xenotransplantation, the main themes among Jewish, Christian and Islamic commentators concerned the duty to heal, the need to treat the whole

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### Table 2. Ethical domains of practical considerations in xenotransplantation

| Ethical domains | Autonomy | Equity | Utility | Justice |
|----------------|----------|--------|---------|---------|
| Racial and ethnic attitudes | Who will be eligible for xenotransplant | Cost of program infrastructure and transplants | Xenotransplant regulatory oversight | Violate the laws of nature; cruelty to animals |
| Extent of informed consent | Availability to groups excluded from transplant now | Potential savings from xenotransplant over allograft | Approval of genetic changes | Availability to groups excluded from transplant now |
| Trans-species infection; chimerism | Insurance coverage public and private | Return on investment to commercial entities involved | Need for more animal models before human trials | Lopsided distribution of healthcare spending |
| Tracking infection risk | Insurance coverage public and private | Concern for monopoly pricing if limited number of providers | Allocation of pig kidneys | Will government cover cost of immunosuppression medications |
| Stigma of having a pig kidney | Number of kidneys needed per transplant | Hyperacute rejection | Tracking pig kidney success | Diversion of money away from primary care |
| Who will be in clinical trials | Who will be eligible for xenotransplant | Tracking infection risk | How to prevent hierarchy of kidneys and of recipients | Who will be in clinical trials |
person and the need to put xenotransplantation in the context of its goals, the effect on the recipient, and the effects on society in terms of equity, justice and cost. A separate discussion of Islamic legal thinking about xenotransplantation examined the inherent contradictions in using an impure animal only if the treatment is considered life-saving [11]. Muhammad Mohiuddin, one of the cardiothoracic surgeons who transplanted a pig heart into a human recipient at the University of Maryland in January, told The New Yorker that as a Muslim he faced resistance from his family when he started to work with pigs. ‘We don’t eat pork or talk about pork.’ But he said after talking to religious leaders, ‘the consensus was that saving lives takes precedence over everything’ [12].

A survey of 1524 Latin American immigrants in Florida found an unfavorable attitude toward xenotransplantation: 10% of respondents approved if the pig organ worked as well as a human organ, while only 2% favored it if the results were worse with a xenotransplant. Attitudes were shaped by age, marital status, social engagement, religious beliefs and attitudes toward deceased organ transplants. Respondents from Honduras and Guatemala were significantly more in favor of xenotransplantation [13]. In a separate study of Spanish veterinary students, researchers found that respondents were generally in favor of xenotransplantation [14].

Black and white patients with kidney disease and Black and white parents of children with congenital heart disease did not differ in attitudes toward xenotransplantation of hearts. But Black kidney patients were less likely than white kidney patients to accept porcine xenotransplantation in part due to psychosocial concerns about the effect of pig xenotransplantation
on the recipient’s personality and social interactions. Overall acceptance of pig kidney transplants was still high among Black respondents, with 70% responding favorably [15].

Attitudes toward xenotransplantation in Asia are influenced unfavorably by Buddhism, Confucianism and Shintoism, but seem to be shifting as scientists in Korea and China become more involved in research on pig xenotransplants of kidneys, corneas and islet cells [16].

Animal rights remain a concern. Religious leaders discussed the need for ‘Stewardship over creation,’ avoiding cruelty to animals in frivolous research. People for the Ethical Treatment of Animals (PETA), an organization opposed to animal experimentation, argued that reports on the xenotransplantation of pig heart and pig kidney should serve as reminders that animal-to-human transplants are unethical, dangerous and a tremendous waste of resources. The group proposed that presumed consent laws, in which people must opt-out of being considered an organ donor rather than opting in, would make more human organs available [17].

**ECONOMIC CONSIDERATIONS**

The financial costs of pig kidney xenotransplantation have been raised in the context of whether it would drain funds away from therapies with a broader impact on public health by pulling money away from primary care. Information on the cost of pig kidney xenotransplantation is sparse. One of the transplant surgeons behind pig xenotransplantation at UAB wrote that ‘it is nearly impossible’ to estimate the cost of a pig kidney xenotransplant once the procedure becomes routine. He cited a list of costs to be considered, including breeding and raising the pigs under bio-secure conditions, the need for separate operating facilities for humans and animals, laboratory facilities, costs for the company providing the organ and the need to recoup its investment, in being able to obtain an organ on demand [18].

Currently, the cost of transplanting a pig kidney is thought to be at least as expensive as transplanting a deceased donor human kidney, with the standard acquisition charge for a kidney from the United Network for Organ Sharing ranging between $26 780 and $38 000 [19]. Even with the extra costs for obtaining organs on demand, other costs like transportation to fly human organs from procuring hospital to receiving hospital would be offset by lower costs of obtaining pig kidneys from regional centers. Moreover, net savings to society from a single viable pig kidney could amount to $1.1 million, with taxpayer savings per kidney of $146 000 [20]. Whether insurers will cover pig xenotransplantation remains an unanswered question. Some argue that insurance coverage of cost-effective interventions depends not only on the actual savings but also on the degree of moral hazard associated with not covering the intervention [21].

UAB received an initial 5-year grant of $19.5 million from United Therapeutics Corporation (UTC) in 2016 to establish a xenotransplantation program [22]. UTC subsidiary Revivicor provided the pig kidneys for the NYU and UAB surgeries as well as the heart to the University of Maryland. According to the UTC website, the distribution of kidneys is planned worldwide.

**MEDICAL CONSIDERATIONS**

Clinical trials of pig xenotransplants are approaching faster than many thought, but not as quickly as some hoped. Major issues like zoonotic infection and hyperacute rejection seemed to have been worked out for a start. Largely using CRISPR/Cas 9 gene editing techniques [23], scientists were able to create the 10-GE pig used at NYU and UAB.

The genetic engineering of pig kidneys grew out of the need to protect it against the human innate and adaptive immune systems [24] and has evolved as the technology of gene editing has progressed. The initial transgenic model includes three alterations: α-1,3-galactosyl transferase knockout, insertion of CD46 human complement regulatory protein and CD47 integrin transmembrane protein to prevent phagocytosis. A 3-genetically engineered pig kidney has been used in pig kidney transplants to non-human primates. One gene knockout pig kidneys have achieved post-transplant survival in macaques of 160–320 days, while baboons that received a kidney from a 6-genetically engineered pig kidneys have survived 136–260 days, using anti-CD40 costimulatory blockade as immunosuppression [25]. Ten changes in the 10-GE pigs used in New York and Alabama include knockouts of three pig enzymes producing carbohydrates not found in humans, removal of the pig growth hormone gene and introduction of two human complement inhibitor genes, two human anticoagulant genes and two immunomodulatory genes. Of note, red blood cells in the 10-GE pigs do not express ABO antigens and can act as universal donors in humans [2] (Table 3).

Other genetic engineering efforts have sought to remove genes for Porcine endogenous retrovirus (PERV) from the pig genome, reflecting concern that the retrovirus could be introduced into the human recipient genome and the wider society since PERV genetic material can integrate into human cells in vitro [26]. No evidence of chimerism, as measured by the expression of porcine large ribosomal protein in the recipient’s blood, was found in the UAB recipient’s blood at any point during the post-transplant period [2], easing some concerns [27].

Efforts to counter the risk of infectious disease transmission have also included screening pigs to be free of bacterial, fungal, parasitic and viral pathogens. Nucleic acid testing has also been developed for porcine viruses [26]. Experts argue that the Porcine Cytomegalovirus (PCMV, a herpes virus more like human Herpesvirus 6 than human CMV) decreases the survival of pig kidneys in non-human primates by deranged coagulation. Eradicating PCMV from donor pigs is seen as the only safe way to prevent transmission via xenotransplantation [28]. The coronavirus 2019 (COVID-19) panic has raised concern about the introduction of a new pathogen into humans. But xenotransplant advocates argue that the differences between the spread of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) and zoonosis after xenotransplantation are great enough to suggest that xenotransplantation is safe [29].

Other medical concerns that have yet to be worked out include how many pig kidneys would need to be transplanted to provide the recipient with adequate small molecule clearance. The total number of nephrons in swine kidneys is greater than in human kidneys (1.6–4.6 million versus 0.2–2.0 million), although pig kidneys are generally smaller than human kidneys (8 cm versus 10–12 cm) [30]. Surgeons at UAB, transplanted both kidneys in their recipient because the nephron mass of the pig kidney is not known and the decedent model would be a good way to test how many pig kidneys are needed to support an adult human [2].

The kidneys were transplanted using standard surgical techniques for heterotopic transplants. Of interest to nephrologists is whether they could use the same techniques to examine urine sediment from a pig xenotransplant in the event of acute injury post-transplant. Pig models of urinary tract infections have identified Tamm Horsfall proteins in areas of tubular destruction [31],
Table 3. 10-genetically engineered pig (10-GE pig) [2, 23]

1. Pig gene knockouts to prevent hyperacute rejection from human antibodies to pig sugars
   a. α-1-3 galactosyltransferase—enzyme responsible for synthesis of galactose-α-1-3-galactose (α-1-3GAL)
   b. β-1,4-N-acetylgalactosyltransferase—enzyme responsible for synthesis of non-GAL polysaccharide DBA-reactive glycan (also known as Sda antigen)
   c. CMP-N-acetyleneuraminic acid hydroxylase—enzyme responsible for synthesis of Neu5Sc
2. Pig gene knockout to prevent excessive growth of pig kidney
   a. Porcine growth hormone receptor gene
3. Insertions of human genes into pig genome
   a. Human compliment inhibitor genes
      i. hDAF—decay accelerating factor, membrane protein that inhibits activation of compliment C3 component
      ii. hCD46—membrane cofactor protein responsible for regulating human compliment cascade
   b. Human anti-coagulant genes
      i. hTBM—human thrombomodulin on pig endothelial cells to inhibit prothrombinase and delay clotting
      ii. hEPCR—endothelial protein C receptor to reduce thrombin generation and platelet aggregation
   c. Human immunomodulatory genes
      i. hCD47—integrin transmembrane protein to prevent phagocytosis (‘don’t eat me’ protein)
      ii. hHO1—heme oxygenase 1 antioxidant enzyme that reduces inflammation and prevents apoptosis

suggesting that nephrologists could examine urine sediment for renal tubular epithelial cells or granular casts. Baboons receiving pig kidney xenotransplants have suffered from a hypovolemia syndrome that persisted despite adequate volume replacement. The cause is not well understood but is thought due to dysregulation of the primate renin–angiotensin system [32, 33]. It is not clear whether the hypovolemia syndrome would be a potential problem in humans and would depend on whether there is enough human renin in end-stage human kidneys or if pig renin will cleave human angiotensinogen to angiotensin 1 at all or at adequate rates. Some authors suggest that pigs may need to be genetically engineered to produce human renin [34].

Concerns about the effects of human growth factors on the pig xenograft grow out of observations that pig kidneys grew in baboons and that there is an 84% similarity between amino acid sequences in pigs and humans. The rapid growth of pig heart transplants has raised concern because of limits to space in the human chest. Pig kidneys would have extra space in the abdomen [35]. In growth hormone-receptor knockout pigs, the weight of the kidney is significantly reduced compared with wild-type pigs [36], raising questions about whether that could cause problems for human recipients. Further, concerns are increased for the production of pig growth hormone with detrimental effects on glomerular filtration rate (GFR) and renal blood flow due to increased arteriolar resistance.

On other physiologic points, pig and human kidneys appear to have similar GFR and renal blood flow, although no direct measurement of pig GFR by inulin clearance after pig kidney transplant to non-human primate has been carried out. The action of pig antidiuretic hormone differs from human antidiuretic hormone because of differences in location of the pig collecting ducts. Pigs have a lower urine osmolality than humans, further suggesting less concentrating ability in pig kidneys than in human kidneys. Proteinuria in adult pig urine and human urine are similar and could be used to assess the damage. Serum concentrations of electrolytes are considered similar although pigs have higher levels of serum potassium than humans (5.3 mEq/L compared with 4 mEq/L) [34].

Questions about derangement of the renin–angiotensin–aldosterone system and growth hormone in pig xenotransplantation also raise questions about other hormonal systems like erythropoietin and Klotho. Researchers have noted a drop in hemoglobin in non-human primates with pig xenotransplant that they attributed in part to incompatibility between pig erythropoietin and primate receptors, administration of myelosuppressive medications and frequent, large-volume blood draws. They wrote that they were able to maintain stable hemoglobin with the administration of recombinant human erythropoietin, which they suggested should help prevent anemia in humans [25].

Experiments showed in vitro that pig endothelial cells incubated in human klotho and then exposed to xenoreactive antibodies and complement had reduced expression of pro-inflammatory genes and reduced complement-mediated cytotoxicity. The expression of anti-inflammatory hormone heme oxygenase 1 was also increased [37].

Compared with humans, pigs generally have higher phosphorus (8.8 mg/dL in genetically modified pigs versus 3–4.5 mg/dL in humans) and calcium levels (10.8 mg/dL in genetically modified pigs versus 8.4–10.2 in humans). Pig xenograft response to human fibroblast growth factor 23 is unknown. The implications for physiologic differences between pig kidneys and human homeostasis are significant for xenotransplantation and may represent barriers to transplanting pig kidneys into humans unless identified early and resolved, according to the authors of a review [34].

**LEGAL/REGULATORY**

Researchers argue that the first human trials of pig xenotransplantation should be with kidneys rather than hearts since kidneys can be removed, immunosuppression stopped and the patient returned to dialysis if acute rejection or systemic infection develops. US regulators may require pre-clinical experiments with non-human primates to show complication-free survival of more than 6 months in six experiments in series. But researchers argue that keeping a baboon alive in an animal care facility with immunosuppression for longer than 6 months would be difficult. Other questions that need to be answered before clinical trials can be approved include whether further genetic modifications in the pig are needed and what drugs should be used for immunosuppression [38]. It remains to
be seen whether US regulators would approve the 10-GE pig as a whole or require approval of each genetic modification separately [39].

The US Food and Drug Administration notes that while ‘the potential benefits are considerable,’ xenotransplantation raises concerns about the potential infection of recipients with recognized and unrecognized infectious agents and transmission to close contacts and the general human population. Potential cross-infection with retroviruses raises a public health concern since they may remain latent and cause disease years after infection [40]. Legal scholars argue that this would require acceptance by the recipient of lifelong monitoring. Not only do patients need to be told that the risk of infection cannot be entirely ruled out, but they would also be required to undergo stringent post-transplant surveillance. Whether they would still have the right to withdraw as a research subject seems unclear. The difficulty then becomes balancing individual autonomy to withdraw from a study against the need to protect public health. Whatever response the state takes must be proportionate to the risk to society and may require the exclusion from trials of patients who may be unlikely to comply with the need for surveillance, these scholars argue. They add that regulation of xenotransplantation should be uniform around the world, with public participation in the review process [41].

SOCIAL JUSTICE/EQUITY

The final concern touches on the selection of subjects for clinical trials and whether xenotransplantation would increase equity and diversity among people who receive a functioning transplant or lead to further hierarchization and injustices in the way organs are allocated. At this point, it is too early to say how pig xenotransplant kidney allocations would be allocated or whether the current Organ Procurement and Transplantation Network and United Network for Organ Sharing would be involved. Some authors have suggested that kidney xenotransplants for dialysis patients or pre-emptive kidney xenotransplants for people before they start dialysis could reduce mortality and serve as a bridge while they wait for an allograft [42].

Discussions on clinical trials appear focused on utility and outcomes. In a recent update on kidney xenotransplantation, researchers with UAB’s xenotransplant program suggested that initial clinical trials could be justified in elderly patients without significant comorbid disease; patients with blood groups that would require long waits for an allograft kidney; recurrent renal diseases like focal segmental glomerular sclerosis, IgA nephropathy, membranoproliferative glomerulonephritis type 2; or loss of vascular access for hemodialysis. Highly sensitized candidates would likely be excluded from initial trials because of the risk of cross-reactivity of human leukocyte antigen antibodies to swine leukocyte antigens (SLA) [43]. Younger patients might be excluded from initial trials since the survival of the pig kidney xenografts is not known and the expectation is that young patients would survive longer. The UAB team has proposed that their initial human clinical trial of xenotransplantation would be limited to four patients over the course of a year. If the first patient remains healthy for over 3 months with good renal function and without major complications like infection, the team would proceed with the second patient. They would follow the patients for a year and then collaborate with regulatory authorities in expanding the trial [38].

SUMMARY

Many of the questions raised here presuppose that pig xenograft kidneys will become a safe option for patients with end-stage kidney disease seeking a kidney transplant. Some have gone as far as to suggest they may even replace the need for human organs. A review of the literature on the ethics of xenotransplantation shows that significant questions remain and should be considered ahead of clinical trials in living recipients. Trials need to be conducted so that findings are widely generalizable. There does not seem to be enough data to speculate on how pig xenograft kidneys would be allocated or how widely they will be available. It is not too early, however, to begin asking the questions given how quickly the science has progressed. Considering existing disparities in human kidney allocation, society would be well served to develop an allocation system for pig kidney xenotransplants that prevents one from evolving that only reinforces inequality in access to kidney transplants and outcomes. Instead, all efforts should be made to create a system in which everyone has access to the treatment on an equal basis and that the benefits and risks of xenotransplantation are spread equally across groups in society.

CONFLICT OF INTEREST STATEMENT

The author declares no financial conflicts of interest. He is a volunteer member of the Rhode Island Hospital ethics committee and a regional representative to the ethics committee of the Organ Procurement and Transplantation Network. The views expressed here are solely his own. This work has not been published elsewhere and is not under consideration by another publication.

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