Modern biotechnology has been spectacularly successful. Advances in the area of fertility have resulted in the birth of "test-tube" babies, and surrogacy has made post-menopausal child-bearing possible. The field of genetic research is seeing dramatic growth in the understanding of the links between genetics and disease, both in terms of predisposition for and actual incidence of disease. Such understanding is paving the way for gene replacement, gene modification and cloning. We are also able to transplant human hearts, lungs, kidneys, livers, corneas, and skin into patients whose own organs are failing. The emerging technology of xenotransplantation involves the transplantation of live cells, tissues, or organs from an animal into persons suffering from various diseases.
Although human-to-human transplantation (allotransplantation) has become a regular, accepted treatment protocol and the success rate of such transplants has grown considerably both in terms of the recipient's quality of life and life expectancy, xenotransplantation is becoming an increasingly popular prospect due to the shortage of human organs. In the United Kingdom at the close of the century, over 5,000 people were waiting for kidney transplants. In the United States, there are currently over 400,000 people waiting for organ transplants. If we were able to extend the waiting lists to reflect the universal need for organs, we would find an astoundingly large number of people awaiting transplants.

Although it may still strike many as an almost unimaginable venture, xenotransplantation is not a completely new notion. Inert heart valves from pigs are already being used in heart valve replacement operations. Tissue for human bones and skin is being grown and developed from pigs. There have been many relatively successful transplants of healthy pancreatic islets from pigs into persons with diabetes whose own islet cells are not functioning properly. There are also experiments in process which involve the implantation of brain cells from pigs into people suffering from Alzheimer's disease.

Among many there is an uneasy feeling that with xenotransplantation, human beings are going a step too far. Such persons assert that xenotransplantation crosses fundamental species lines drawn by nature itself or God. Instead of respecting and following nature or God's design, we are now interfering with nature and "playing God." Although xenotransplantation may indeed raise unique ethical issues, the problem with this latter argument is that medicine may be said to be playing God whenever it interferes at all in any natural process. Furthermore, farming and agricultural methods seem to have been crossing the species lines for centuries without either qualm or negative consequence.

This response to the charge that xenotransplantation is "playing God" is not intended to defend the notion that there are no limits to the ways in which human beings should seek to preserve or restore health. Medicine indeed exists in order to help preserve the lives and well-being of people, but at times it may seem to go too far in trying to preserve life by any means and at any cost. This reality should drive us to reflect on what we really mean by "sanctity of human life" and to consider whether we are in danger of trying to resist death unduly. The practice of medicine soon reveals that human life, as well as the fields of science and medicine, are limited. The success of medicine has at times given the impression that life can be endless - that we can all be one hundred percent healthy and that science will solve all of our medical and other problems. None of that is true. The challenge is to determine what limits we will live with and how we will come to terms with the reality that death is a certainty and that none of us will ever attain perfect health and well-being during our lives on this earth.
The main concern among the scientific community in examining xenotransplantation has been the threat from PERVs (porcine endogenous retroviruses). We have seen the dangers of animal-to-human disease transmission and are aware that such transmission is an alleged cause of the introduction of HIV and AIDS to the human race. These medical problems have made researchers rightfully cautious about proceeding with animal-to-human transplantation until there is a general consensus that PERVs will not unleash some kind of "plague" and until adequate surveillance and biosecurity are in place to control any and every unforeseen outbreak.

In addition to the above technical concerns, there are also concerns about possible emotional responses to xenotransplantation. The "yuk" factor plays a significant role in the public's response to all kinds of biotechnological developments. The basis of such a negative emotional reaction may be some deeply-seated human response to going beyond what we consider to be proper natural limits. Certainly the "yuk" factor has played a key role in limiting some biotechnological endeavors. This was evident in the UK when the Human Fertilization and Embryology Authority banned the fertilization of eggs obtained from aborted female fetuses following a public outcry in which many expressed their disgust with such a procedure.

Concerns such as those stated above have prompted some to endorse alternatives to xenotransplantation. There are, however, various problems with these alternatives. For example, the British Medical Association and others have begun to argue for presumed consent for organ removal and donation as a means of combatting the existing organ shortage. This move raises difficult questions about the "ownership" of organs and bodies, especially after death. Many public campaigns have been organized to encourage more people to voluntarily donate their organs; however, in spite of alleged public support for these campaigns, a large number of individuals continue to fail to fill out organ donor cards or to check the appropriate box on their driver's license.

One of the fundamental problems associated with human-to-human transplantation is the dilemma of how we define death. Death was once defined as the cessation of breathing, but was later redefined as the cessation of a heartbeat. Once it was determined that people could be resuscitated, brain death became the criterion for declaring that a person had died. Brain stem death is currently the most reliable and widely accepted criterion for establishing that someone is dead. The use of living donors is one way to avoid questions surrounding the definition of death, but this alternative may also be fraught with moral dilemmas. For example, if a living kidney donor finds that his or her remaining kidney fails, should he or she be permitted to jump ahead in the queue of persons awaiting a kidney transplant?

Another alternative, designated the "Exeter" protocol in the UK, consists of a system of elective ventilation for dying patients. With their and their families' consent, such patients would be moved to an intensive care unit where they would be placed on a ventilator in order to keep their organs in good shape for transplantation. However, problems quickly arose when objection to such use of limited expensive resources was voiced, as well as when some of these patients began to improve because of the ventilation - raising questions about what should be done with them.
In response to the above problems, researchers have attempted to develop artificial organs for transplant into humans. This has been more successful in transplants of the heart than of other organs, but even in heart transplantation the artificial organs may present considerable problems.

Xenotransplantation provides one extreme measure of hope for those who face certain death, offering the possibility of a clear and real benefit to individuals in need of transplants. While this may be a good, there needs to be a careful calculation of the benefit to the individual over against the risk to the community. At present, the calculation underscores the need to protect the community by refraining from performing xenotransplantation procedures. However, it will never be possible to ensure that there are no negative consequences or risks associated with xenotransplantation or any other medical intervention.

Medicine is never a fool-proof science with zero risk. With every procedure, there may be variables which cannot be controlled. While this does not give physicians and scientists a license to be careless, we would do well to recognize that there must come a point where the risk of a procedure is negligible and the expected benefit so great that some degree of risk can be justified.

It is noteworthy that every country which is considering the regulation of xenotransplantation has put in place stringent biosecurity arrangements even before permission to proceed has been given. While we cannot guarantee that such arrangements will safeguard human well-being in every possible situation, we should nevertheless strive for the very highest and best biosecurity possible. In the desire to foster the progress and development of medical science and to save human life, we need to realize the importance of asking moral questions. Just because we may have the ability to do something does not mean that there is a technological imperative which demands that we do it - just because we can do something does not mean that we ought to do it. We need to look carefully at the technology itself, the motives for its use and development, the nature of what is involved in using that technology, and the likely consequences which may follow from its application. Only then can we properly employ that technology to better human health and well-being.

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