

ARTICLE

The Moral Superiority of Bioengineered Wombs and Ectogenesis for Absolute Uterine Factor Infertility

Evie Kendal^{1*} and Julian J. Koplin²

¹Department of Health Sciences and Biostatistics, Swinburne University of Technology, Hawthorn, Victoria 3122, Australia

²Biomedical Ethics Research Group, Murdoch Children's Research Institute, Melbourne Law School, The University of Melbourne, Carlton, Victoria 3010, Australia

*Corresponding author. Email. ekendal@swin.edu.au

Abstract

This paper argues that uterine transplants are a potentially dangerous distraction from the development of alternative methods of providing reproductive options for women with absolute uterine factor infertility (AUI). We consider two alternatives in particular: the bioengineering of wombs using stem cells (which would carry fewer risks than uterine transplants) and ectogenesis (which would not require surgical intervention for either the prospective mother with AUI or a womb donor). Whether biologically or mechanically engineered, these womb replacements could provide a way for women to have children, including genetically related offspring for those who would value this possibility. Most importantly, this alternative would avoid the challenge of sourcing wombs for transplant, a practice that we argue would likely be exploitative and unethical. Continued research into bioengineering and ectogenesis will therefore remain morally important despite the recent development of uterine transplantation, even if the procedure reaches routine clinical application.

Keywords: uterus transplant; UTx; bioengineered womb; ectogenesis; pronatalism; reproductive liberty; artificial womb; transplant ethics

Introduction

Absolute uterine factor infertility (AUI) accounts for approximately 3% of infertility cases in cisgendered women.¹ Heretofore, this condition has been considered untreatable, with women suffering AUI representing the only female infertility group for whom traditional assisted reproductive technologies alone, such as *in vitro* fertilization (IVF), yield no benefit.² Up until recently, the only chance for these women to become mothers was through adoption or engaging a gestational surrogate, if they were financially, legally, and culturally able to do this. Only the second of these options makes it possible for women to be genetically related to the resultant offspring, and there are some groups of women for whom the lack of a gestational relationship carries social and legal challenges to their status as mothers. For example, the United Kingdom's *Human Fertilisation and Embryology Act 2008* stipulates that "The woman who is carrying or has carried a child as a result of the placing in her of an embryo or of sperm and eggs, and no other woman, is to be treated as the mother of the child."³ Similarly, certain cultural and religious groups forbid surrogacy as a means of creating a family, such as Sunni Muslims.⁴ Uterine transplantation (UTx) is a novel surgical intervention that aims to provide women with AUI the opportunity to become gestational mothers as well as genetic or social mothers, by transferring a uterus from a live or cadaveric donor and establishing a pregnancy within the body of the intended mother.

The first UTx was conducted in 2000 in Saudi Arabia, but the organ failed due to blood clotting.⁵ Another attempt was not recorded until 2011, when a Turkish woman received a transplant uterus via

cadaveric donation, but was subsequently unable to sustain a pregnancy.⁶ While the organ was functional, Dr. Ömer Özkan told the media at the time: “The surgery was a success. But we will be successful when she has her baby.”⁷ This highlights the uniqueness of UTx compared with most other organ transplants, as the typical recipient wants not merely to *have* a functional uterus, but to *use it for procreative purposes*.⁸ Giuseppe Benagiano et al. note that while the procedure might have much in common with other “quality of life” enhancing transplants, such as for the hand or face, it is not life-prolonging and does not provide health benefits for recipients.⁹ As such, the risk–benefit analyses that clearly favor solid organ transplantation as a life-saving or health-enhancing intervention do not apply to UTx, and we further argue that they cannot be used to justify live or cadaveric donation.

Although UTx incorporates ethical issues from both the assisted reproduction and organ transplant spheres, it also presents a number of unique challenges. The first live birth from a transplanted uterus was achieved in Sweden in 2014, and according to Michelle Bayefsky and Benjamin Berkman the announcement in *The Lancet* in October 2015 “made international headlines and was touted as a miracle and medical marvel.”¹⁰ We find such language provides evidence of our major concern with UTx—namely, that its novelty may obscure some of these unique ethical issues from view. Beyond the fact UTx is intended to be “life-propagating” rather than “life-saving,” Michael Olausson et al. note that UTx is “the first ephemeral transplantation type,” highlighting that following reproductive success it is anticipated that the organ would be removed, thus also removing the need for the recipient to take antirejection medication.¹¹ The fact that a pregnancy established in a transplant uterus might carry undue risk to a developing fetus, especially if the organ failed and needed to be removed, also represents a potential ethical dilemma not faced in other transplant types. Finally, UTx raises a unique organ allocation dilemma: whether transgender people would be considered candidates for UTx. The key question here is whether genetic females born without a uterus have a greater claim to uterus transplantation than transgender women, who may be socially infertile for the same reason. Gender expression is not a consideration that usually impacts organ allocation decisions (as most human organs are not sex-specific); in the specific context of UTx, the relevance of gender expression to organ allocation protocols remains a live question.

In this paper, we point toward a number of ethical challenges raised by UTx. Many of these challenges may be surmountable. However, some of these challenges—such as that of finding reliably ethical sources of transplant organs to support the procedure—would be very difficult, if not impossible, to fully resolve. Due to a combination of issues surrounding pronatalism, exploitation, and clinical risk, we consider bioengineered wombs to be morally superior to UTx as a future treatment for AUFU, as they could achieve the same objective of establishing a pregnancy within the body of the intended mother without subjecting donors or their families to unreasonable risk or harm. Ectogenesis would further reduce these risks by providing an alternative site for gestation that does not require surgical interventions for the prospective mother with AUFU, while also avoiding the complications of engaging a surrogate. Whether biologically or mechanically engineered, these womb replacements could provide a way for women to have children, including genetically related offspring for those who hold this value. Most importantly, these alternatives would negate the need for antirejection medications that might have an adverse effect on offspring and avoid the challenge of sourcing wombs for transplant; a practice that we argue may often be exploitative and unethical. By drawing parallels with gestational surrogacy and live kidney donation, this paper will argue that UTx should not be regarded as having solved the problem of AUFU; it is morally important to continue research into bioengineering and ectogenesis.

Ethical Considerations for Recipients and Fetuses

From the perspective of recipients, UTx is clearly more risky than either adoption or gestational surrogacy. Unlike in many other transplants, the risks involved in the surgery itself and the prolonged use of antirejection medications cannot be weighed against the benefit of saving a life, as the function being restored is reproductive not vital. Some bioethicists argue this means the threshold for justification

of the procedure should be higher than for other transplants,¹² especially in cases where gestational surrogacy is available as a safer alternative.¹³ Kavita Arora and Valarie Blake remind us that for many women with AUI simply having a child is not enough; they wish to be “visibly pregnant, emotionally pregnant, and seen as pregnant by society,” a desire that surrogacy does not accommodate.¹⁴ Adoption also fails to provide this experience. These authors note that in a pronatalist society, even morning sickness and pregnancy weight gain can be highly valued symbols.¹⁵ However, while UTx certainly provides a closer approximation of natural reproduction, given the fact a transplanted uterus would not have nervous innervation, the sensations of pregnancy would be quite different. Thus, Bayefsky and Berkman claim that unless fully informed, prospective recipients may “overrate” how similar the experiences would be, and women “might feel alienated from the transplanted organ” due to this lack of innervation.¹⁶

Much of the ethical debate surrounding UTx focuses on the need for informed consent from recipients. Arthur Caplan et al. claim women are “willing, even eager” to take the risks associated with experimental UTx for the chance to experience pregnancy,¹⁷ which we argue is likely influenced by pronatalistic social pressure. Pronatalist dogma prioritizes childbearing as a social duty for women even when significant obstacles must be overcome to achieve reproductive success, as in the case of infertility.¹⁸ While this pressure exists for all women in society, regardless of fertility status, a desire to avoid the stigma of infertility might leave women with AUI particularly vulnerable to its influence. Zubia Mumtaz and Adrienne Levay further claim that in some low-income pronatalistic societies where women’s value is still significantly determined by childbearing capacity, a truly noncoerced decision to pursue UTx might be impossible.¹⁹ Using Pakistani women as an example, these authors note that fertility treatment decisions are often made by mothers-in-law, rather than the women themselves, and that failure to produce sufficient offspring leaves these women susceptible to “physical, mental, and emotional abuse,” social discrimination, and psychological distress.²⁰

The risks of stigma, discrimination, and psychological distress are also morally significant beyond the challenge they pose to informed consent. Being subjected to social and interpersonal pressures to undergo UTx would be harmful even if these pressures are not so great that they altogether override the possibility of obtaining informed consent.²¹ For those who experience these pressures, deciding not to pursue UTx would come at a cost. In some contexts, merely having the option of undergoing UTx may therefore be harmful, especially insofar as there are few alternative means of overcoming AUI. Even assuming it is possible to obtain informed consent for UTx, at least in some circumstances or to a standard that is equivalent to other reproductive decisions, there are still a number of ethical considerations that warrant special attention. One is the need to create comprehensive allocation protocols for the transplant organs, as existing methods are not suited to UTx. Arora and Blake note prioritization on the basis of “sickest first, best prognosis or quality of life assessments” are not relevant in the case of UTx, as all potential recipients would be expected to maintain the organ for a similar length of time, and “nobody is more or less infertile than the next.”²²

In terms of safety issues, in addition to the risks of anesthesia and surgery, UTx provides diagnostic challenges regarding graft rejection. Liza Johannesson and Stina Järholm note that the uterus has no distinctive blood marker that might indicate organ rejection, unlike the pancreas, liver, or kidneys.²³ This is particularly problematic when considering significant organ damage could occur before rejection is clinically detected, and if the transplant organ needed to be removed after a pregnancy had been initiated this might entail loss of fetal life. Other valid concerns for maternal and fetal well-being relate to the increased blood flow through the uterine arteries needed in pregnancy, increasing the risk of blood clots, preeclampsia, and placental ischemia.²⁴ Whether children who were gestated in a transplanted uterus should be informed of this fact is another ethical consideration that mimics existing IVF, donor insemination, and adoption cases.²⁵ Additionally, Caplan et al. claim that incidental fetal exposure to antirejection medication—for example, for a liver transplant patient who later becomes pregnant—is not morally equivalent to the deliberate exposure entailed in UTx, where the use of the drugs is “solely for the purpose of carrying a pregnancy.”²⁶ Finally, it is worth noting that risk–benefit analyses of UTx have disregarded the impact of long-term immunosuppression on recipients under the assumption that the transplanted uterus would be

removed, and with it the need for antirejection drugs.²⁷ As such an intervention would require the voluntary consent of the recipient, this outcome cannot be assumed in every case.

Regardless of the significant risks to UTx recipients, the demands of reproductive liberty provide strong support for the conclusion that women with AEFI should be free to pursue UTx in contexts where it is available. The contrary position might inadvertently cast high-risk natural pregnancies as morally impermissible, by implying that levels of reproductive autonomy should be graded by severity of risk. When comparing potential harm to fetuses gestated in transplanted wombs with the alternative of nonexistence, there is similarly a presumption in favor of UTx.²⁸ However, a hypothetical right to pursue a future treatment *if* it becomes widely available does not suggest that it *should* be adopted as an appropriate treatment for AEFI. That UTx does not actually cure AEFI so much as circumvent it, and pregnancies in a transplanted uterus are not equivalent to those within a native womb, indicates to us that further research needs to be conducted to develop safer, more satisfactory fertility solutions for women with AEFI. (While not the focus of this paper, these arguments also bear relevance for other noncurative treatments and transplant types.) Due to concerns with ethically obtaining suitable organs for transplant, we argue UTx should not become normalized as *the* treatment for AEFI. To demonstrate this point, we will now outline some of the issues surrounding cadaveric and live uterus donation, before discussing the moral superiority of alternatives, such as bioengineered wombs and ectogenesis.

Cadaveric Donation as Postmortem Surrogacy

Due to the risks associated with being a live organ donor, fertility clinics embarking on UTx in the United Kingdom initially forbade using live donors, and the Cleveland Clinic in the USA has still opted exclusively for cadaveric donations.²⁹ In 2016, Nicola Williams noted that while at that time all of the successful live births following UTx had been the result of live donors, some scientists working in the area believed the opportunity to harvest more extensive vasculature from deceased donors would in time decrease the risk of thrombosis and necrosis, such as was seen in the Saudi case.³⁰ The Cleveland clinic has since achieved live births from cadaveric donated uteruses, with the first in 2019.³¹ However, the issue of increased ischemic time for a cadaveric donation and the associated increase in graft rejection rates remain a problem.³²

Beyond the technical constraints, the use of cadaveric donation for UTx carries various ethical concerns. Many of these concerns directly relate to the fact UTx is not lifesaving and involves a reproductive organ. As George Agich notes:

A strongly valued goal, such as restoring basic physiological functions essential for life, is required to warrant the desecration of a corpse and the removal of organs. Traditional organ transplantation was based solidly on the ethics of rescue that permits exceptional efforts to be undertaken to save lives that are in immediate danger.³³

While a comparison can, and often is, drawn between UTx and face and hand transplants (neither of which constitute “efforts to save lives that are in immediate danger”), Arora and Blake note these transplant surgeries are still very rare, and hospitals have typically required special consent procedures from donor families in recognition of the difference between saving a life and improving the quality of that life through transplantation.³⁴ Further relevant differences can be seen between potentially saving a woman’s life and providing a means for her to gestate future offspring.

Caplan et al. claim that women who have currently signed donor cards have done so with implicit knowledge that their reproductive organs were not among those to be harvested, suggesting that transplant teams would “be on firmer moral ground” if they only considered cases where women had explicitly consented to their uterus being donated.³⁵ However, this stipulation would severely limit the number of organs available for transplant, especially considering the requirements of quality, matching, timing, and other transplant criteria.

The use of cadaveric donation in UTx to create a child also brings with it concerns regarding the donor family's potential relationship with that child. In some ways, UTx could be viewed as a form of postmortem surrogacy, and thus the ethical concerns surrounding gestational surrogacy bear some relevance to this debate. Marilyn Bartucci's study of donor families' attitude toward donation in the late 1980s indicated families were "looking for some type of immortality for their loved one," believing they somehow "lived on" through the life of the transplant recipient.³⁶ Sensationalist media coverage of donor families bonding with recipients or experiencing unusual phenomena as a result of the transplanted organ seem to perpetuate the idea that the donor somehow cheats death through donation. Although this may be comforting for family members and not necessarily problematic in the case of nonreproductive organs, an NBC news report in 2013 highlights that donor families often conceive of the donated organ as still belonging to their loved one. Two mothers who met the recipients of their children's hearts described the experiences as follows:

When I hugged her, I could feel his heart [...] I could feel it pounding. It was hard to let go.

He sat down on the couch that Emily would lay on when she would watch TV [...] He let me lay my head on his chest. I felt her heart beating against my ear. I heard her heart beating strong. [...] These people are meant to do something good [...] We joked around with him: We think you got the heart because you're going to find the cure for diabetes.³⁷

It is not unreasonable to suggest that the families of UTx donors might feel a similar connection to the uterus of their loved one, and that much like in the case of some children of gestational surrogates, may feel as if they share some bond with the resultant offspring. David Orentlicher claims UTx is the only way for a woman with AUI to avoid "shar[ing] her parenthood with another woman," as is seen in gestational surrogacy³⁸; however, this might not preclude the donor's family from feeling a sense of entitlement to the fruits of the donated womb, so to speak. While it is impossible to speculate on how this novel transplant arrangement might be perceived by donor families, it is worth considering the potential implications of confused familial ties before embracing this procedure.

Although many of the ethical criticisms that apply to gestational surrogacy are clearly not relevant in the context of UTx using a cadaver organ—including shifting the risk of pregnancy-related morbidity and mortality onto another woman—other concerns remain. For example, arguments that surrogacy risks instrumentalizing women's reproductive abilities and perpetuating pronatalist views of the role of women as mothers in society (which are often raised in discussions of surrogacy)³⁹ may, with some modification, also apply to UTx. At the same time, it is worth noting that although the burdens of surrogacy are different from the burdens of uterus donation, uterus donation is not without its burdens. As John Robertson argues:

Uterine transplantation appears to be a way out of the surrogacy dilemma for women with uterine factor infertility. With transplant the infertile woman would then be able to gestate, with no split between the genetic and gestational mother, thus, internalizing the burdens that surrogacy shifts to another woman. In the case of living uterus donors, however, another woman is still bearing a significant bodily burden to enable the infertile woman to rear her own child, though the donor is not gestating. With cadaveric organs, the donor family's burdens have psychological but not physical significance.⁴⁰

Whether there would be a consequential increase in the psychological burden of making organ donation decisions in the absence of a clear directive regarding *reproductive* organs is yet to be seen; however, the possibility warrants closer examination. At least intuitively there seems to be a morally relevant difference between donating someone's reproductive versus nonreproductive organs, especially if donor families feel some responsibility for providing not the means to save an existing life, but that which is

required to create *new* lives. The above quote also relates to our next key argument that live uterus donation represents a significant burden on donors.

Live Donation as Archetypal Maternal Altruism

Being a live donor for UTx carries similar clinical risks as other forms of live donation, including blood clots, hemorrhage, adverse anesthetic events, and infection, with no concomitant health benefit for the donor. When compared to a standard hysterectomy, the risks might be further exacerbated by the need to harvest additional vasculature to achieve transplant success.⁴¹ For postmenopausal donors, the use of hormone therapy prior to surgery also increases the risk of blood clots forming pre and postoperatively.⁴² Olausson et al. note that while there are no available data on the risks of hysterectomy among healthy patients, large data sets yield rates of injury for those undergoing the procedure for benign uterine disease at 1–2% for bladder injury, 0.1–0.5% for ureter injury, and 0.1–1% for intestinal injury.⁴³ Even in the absence of these negative outcomes, Williams notes:

Retrieval from the living *necessitates* physical harm to the donor and includes small but not insignificant risks of long-term morbidity and mortality thought similar to, or only slightly higher than that of a total abdominal hysterectomy.⁴⁴

Nevertheless, there are various reasons why live donation for UTx is more likely to be successful—as has previously been the case with kidney transplantation—including the fact that the surgery can be timed such that both patients can be prepared for the operation.⁴⁵

Beyond the physical risks to live donors, Robertson considers the psychological issues that would need to be addressed to ensure “the donor does not believe that she is ‘the mother’ of the child” gestated in her donated organ.⁴⁶ He also notes that especially in cases where the intended mother has eschewed gestational surrogacy in favor of UTx from a live donor, that she must be cognizant of the substantial burden this has imposed and “the obligations of reciprocity which that would entail.”⁴⁷ This might include agreeing to support a relationship between the donor and any children gestated following UTx. Other psychological risks to donors include possible problems with sexuality and gender identity postdonation, based on current knowledge regarding hysterectomy patients.⁴⁸ Such considerations form part of the cost–benefit analysis each donor–recipient pair would need to calculate before embarking on such an endeavor, requiring realistic expectations on both sides of the rates of transplant success.⁴⁹

One major ethical dilemma surrounding live donation for UTx is the potential for a commercial market to arise, where disadvantaged women are coerced into donating their uterus for money. Ostensibly such a market should be simple enough to ban by limiting to altruistic donation; however, the parallel case of live kidney donation demonstrates that even when commercial donation is illegal, poor and vulnerable individuals will still be targeted to sell their organs.⁵⁰ Thus, Mumtaz and Levay claim transnational uterus donation has the potential to “encroach on women’s human rights in places where they already have little decision-making power or rights,” such as low-income countries.⁵¹ Of course, much as the practice of illegal kidney trafficking has not led us to block all forms of kidney transplantation, the possibility of an exploitative trade in uteruses may not by itself be sufficient to block UTx outright. However, as we argue below, the burdens associated with this procedure may constitute an unreasonable demand on *any* woman, regardless of whether any monetary incentive is provided.

There is a well-documented gender imbalance in living organ donation. Using kidney donation as an example, although many more women than men opt to become living organ donors, they are less likely to receive a kidney. It is both more common for wives to donate a kidney to their husband than it is for husbands to donate a kidney to their wife, and more common for mothers to donate to a son or daughter than for fathers to do the same.⁵² Although the reasons for this discrepancy are not fully understood, they likely include the greater likelihood that women will view donation as a parental or spousal duty, that

women are more susceptible to pressure to donate, and/or that broader structural inequalities between men and women render donation less disadvantageous for women than for men (because, e.g., women are more likely to receive a lower salary and/or have a more flexible schedule than men).⁵³ The fact that women are already vulnerable to pressures to become live organ donors makes it particularly difficult to obtain voluntary consent in the context of an organ that *only* women can provide, and that mothers in particular are well-positioned to donate. As first-degree relatives are more likely to provide a match for transplant, and mothers are expected to have completed childbearing by the age their daughters might be seeking UTx, it is reasonable to assume mothers will be among the most common live donors. The perceived demands of “parental duty” and the broader impact of pronatalist dogma may exert a strong influence on the decision to become a uterus donor, and in so doing would arguably impede live donors’ ability to make noncoerced decisions.

In the Swedish trial, eight of the nine donors were mothers or close genetic relatives (e.g., sisters) of the recipient, with the ninth case being a close friend.⁵⁴ Concerns that women may seek UTx due to “an internalized stereotype that a woman is not whole unless she bears and rears her own child”⁵⁵ go some way toward explaining why a mother might feel particularly compelled to donate their uterus to their daughter, especially in cases where she was born without a uterus. That mothers might blame themselves for their daughters’ structural infertility creates another source of pressure complicating the decision to donate. Janice Raymond claims that while men are often socialized to be able to rationalize self-interest, women, and particularly mothers, are painted as the “archetypal altruists,” paragons of self-sacrifice who are expected to put the needs of their children above all else.⁵⁶ In the face of such enculturation a genuinely free choice to donate a uterus to a daughter with AUFU might be difficult to achieve.

Live donor uterus transplantation is therefore ethically fraught. This is not to say that the use of living donors is ethically unjustifiable; we leave this question open. We are defending the more modest claim that there are strong moral reasons to continue to investigate alternative means of treating AUFU, despite the therapeutic potential of UTx.

The Moral Superiority of Alternatives to UTx

As outlined above, there are ethical issues surrounding both cadaveric and live donation that we argue cannot readily be met. Of course, careful regulation may be able to mitigate these issues. However, it is worth noting that the more aggressively UTx is restricted in order to mitigate these concerns, the more likely it becomes that the organ supply might dwindle to the point where UTx is only available to a rare few, if at all.

Pursuing UTx on any major level would require us to consider how the goal of minimizing relevant ethical concerns should be balanced against the goal of ensuring a sufficient supply of transplantable uteruses. (If the supply of uteruses is scarce, resource allocation dilemmas would also arise.) However, this issue is secondary to the main objective of this article, which is to establish that UTx is a potentially dangerous distraction from the development of alternative treatments for AUFU. Even Dr. Mats Brännström, team leader of the Swedish uterine transplant trial, believes that bioengineering wombs using stem cells would be a superior treatment for AUFU, reducing or eliminating many of the risks associated with uterine transplant for both the donor and recipient.⁵⁷ Using an artificially created womb built from patients’ own cells also means fetuses would not be exposed to antirejection medications and women may feel as if they are experiencing a more genuine pregnancy, less alienated from an organ built from “self” tissue than one that was “foreign.” There would also be no need to remove the organ after use, which may have a positive impact on sexual identity for women with AUFU, who could justifiably desire an intact uterus for reasons of bodily integrity separate from reproduction.⁵⁸ Ariel Lefkowitz et al. note both desires might also arise in transgender women, whose claims to treatment for AUFU may be deemed equivalent to other women, as “The principle of autonomy is not sex-specific.”⁵⁹ A bioengineered womb would allow women to control maternal lifestyle influences on fetal development—one of the major

benefits Brännström sees to UTx⁶⁰—while *also* avoiding potentially harmful exposure to antirejection medication.

On the surface, it may appear as if allowing UTx to develop into the preferred method of treatment for AEFI is not harmful to anyone, even considering the reality of scarce transplant resources. It might also be thought that UTx is ethically preferable to surrogacy (and in particular transnational commercial surrogacy), which is at present the main means by which women with AEFI can achieve genetic motherhood. Nevertheless, UTx does not cure AEFI in the way a bioengineered womb might, and if IVF is any indication, once a method of circumventing infertility to promote childbearing is achieved, the motivation to find genuine cures for the underlying condition deteriorates. Thus, by allowing a small number of women to take advantage of UTx, not only would we be promoting the likely exploitation of donors, both domestically and internationally, but also potentially derailing research into more beneficial treatments focused on women's health and wellbeing, rather than solely the goal of producing offspring. A future bioengineered womb could satisfy a woman's desire to become a mother, genetically, gestationally, and socially, at much lower risk than that which is provided through UTx, as graft rejection issues could be avoided, and with no harm to third parties.

For those women who are less concerned with gestational motherhood, the potential for artificial gestation, or ectogenesis, might also be an appealing alternative to pregnancy. This option might prove valuable for women with AEFI, transgender women, or any woman who wishes to have genetically related offspring without being pregnant or engaging a surrogate. As ectogenesis would eliminate the risks of pregnancy-related morbidity and mortality from mothers and surrogates and would not depend on exploiting maternal altruism to procure scarce organs through invasive surgery for transplantation, we argue this gestational alternative would be morally superior for women with AEFI. Although there are many ethical issues surrounding the potential development and regulation of ectogenesis services that would need to be addressed before the technology could be released, for the purposes of our argument, the central defense for investing in this technology as a reproductive option for women with AEFI revolves around the fact that *all* other means of gestating children involve significant risks and burdens to women, rather than objects. UTx merely represents an extreme example of these risks, to intended mothers and uterus donors, and is a procedure whose normalization in fertility care we argue can still be prevented. Thus, while respecting reproductive liberty might demand that UTx be tolerated to a degree, we maintain that this should only be permitted if it does not serve to impede progress toward other treatments, such as bioengineering and ectogenesis.

Conclusion

In conclusion, due to concerns with organ procurement, allocation, and transplantation procedures, we argue that UTx is not a safe solution to AEFI. We have pointed toward the risk that if UTx reaches clinical application, it will lessen the drive to develop alternative methods by which women with AEFI can have a genetically related child, such as ectogenesis or the bioengineering of wombs. We defend the position that these future technologies represent morally superior alternatives to UTx and should therefore shape the direction of fertility treatment for AEFI cases and beyond.

Notes

1. Arora KS, Blake V. Uterus transplantation: Ethical and regulatory challenges. *Journal of Medical Ethics* 2014;**40**:396–400.
2. Olausson M, Johannesson L, Brattgård D, Diaz-Garcia C, Lundmark C, Groth K, *et al.* Ethics of uterus transplantation with live donors. *Fertility and Sterility* 2014;**102**(1):40–3.
3. UK. *Human Fertilisation and Embryology Act 2008*, at s33(1).
4. Inhorn M. Making Muslim babies: IVF and gamete donation in Sunni versus Shi'a Islam. *Culture, Medicine and Psychiatry* 2006;**30**(4):427–50.

5. Daar J, Klipstein S. Refocusing the ethical choices in womb transplantation. *Journal of Law and Biosciences* 2016;3(2):383–8.
6. See note 5, Daar, Klipstein 2016, at 383–8.
7. RT News [Internet]. *World's First Successful Uterus Transplant Performed in Turkey*; 2011; available at <https://www.rt.com/news/first-uterus-surgery-success-845/> (last accessed 20 Mar 2017).
8. Bayefsky MJ, Berkman BE. The ethics of allocating uterine transplants. *Cambridge Quarterly of Healthcare Ethics* 2016;25:350–65.
9. Benagiano G, Landeweerd L, Bronsens I. Medical and ethical considerations in uterus transplantation. *International Journal of Gynecology and Obstetrics* 2013;123:173–7.
10. See note 8, Bayefsky, Berkman 2016, at 350.
11. See note 2, Olausson et al. 2014, at 40.
12. See note 1, Arora, Blake 2014, at 396.
13. Caplan AL, Perry CM, Plante LA, Saloma J, Batzer FR. Moving the womb. *Hastings Center Report* 2007;37(3):18–20.
14. See note 1, Arora, Blake 2014, at 398.
15. See note 1, Arora, Blake 2014, at 398.
16. See note 8, Bayefsky, Berkman 2016, at 351.
17. See note 13, Caplan et al. 2007, at 18.
18. Fischer E, Otnes C, Tuncay L. Pursuing parenthood: Integrating cultural and cognitive perspective on persistent goal striving. *Journal of Consumer Research* 2007;34(4):425–40.
19. Mumtaz Z, Levay A. Ethics criteria for uterine transplants: Relevance for low-income, pronatalistic societies? *Clinical Research and Bioethics* 2017;S1:004. doi:10.4172/2155-9627.S1-004.
20. See note 19, Mumtaz, Levay 2017.
21. Koplun J. Choice, pressure and markets in kidneys. *Journal of Medical Ethics* 2017;44(5):310–3.
22. See note 1, Arora, Blake 2014, at 399.
23. Johannesson L, Järholm S. Uterus transplantation: Current progress and future prospects. *International Journal of Women's Health* 2016;8:43–51.
24. See note 9, Benagiano et al. 2013, at 174; See note 5, Daar, Klipstein 2016, at 383.
25. Leysner-Whalen O, Temple JR, Phelps JY. Ethical and psychosocial impact of female infertility. *Current Obstetrics and Gynecology Reports* 2012;1:153–8.
26. See note 13, Caplan et al. 2007, at 19.
27. Farrell RM, Falcone T. Uterine transplant: New medical and ethical considerations. *The Lancet* 2015;385:581–2.
28. Catsanos R, Rogers W, Lotz M. The ethics of uterus transplants. *Bioethics* 2013;27(2):65–73.
29. Robertson JA. Other women's wombs: Uterus transplants and gestational surrogacy. *Journal of Law and the Biosciences* 2016;3(1):68–86.
30. Williams N. Should deceased donations be morally preferred in uterine transplantation trials? *Bioethics* 2016;30(6):415–24.
31. <https://health.clevelandclinic.org/for-the-first-time-in-north-america-woman-gives-birth-after-uterus-transplant-from-deceased-donor/>
32. See note 23, Johannesson, Järholm 2016, at 45.
33. Agich GJ. Extension of organ transplantation: Some ethical considerations. *The Mount Sinai Journal of Medicine* 2003;70(3):142.
34. See note 1, Arora, Blake 2014, at 397.
35. See note 13, Caplan et al. 2007, at 19.
36. Bartucci MR. Organ donation: A study of the donor family perspective. *Journal of Neuroscience Nursing* 1987;19(6):307.
37. NBC News [Internet]. *'I Could Feel His Heart': Organ Donor Families Bond with Recipients After Transplants*; 2011; available at <http://www.nbcnews.com/health/i-could-feel-his-heart-organ-donor-families-bond-recipients-2D11648771> (last accessed 20 Mar 2017).
38. Orentlicher D. *Toward acceptance of uterus transplants*. *Hastings Center Report* 2012;42(6):13.

39. Satz D. *Why Some Things Should Not Be For Sale: The Moral Limits of Markets*. Oxford: Oxford University Press; 2010:81.
40. See note 29, Robertson 2016, at 71.
41. See note 1, Arora, Blake 2014, at 397.
42. See note 27, Farrell, Falcone 2015, at 581.
43. See note 2, Olausson et al. 2014, at 42.
44. See note 30, Williams 2016, at 418.
45. See note 23, Johannesson, Järholm 2016, at 45.
46. See note 29, Robertson 2016, at 72.
47. See note 29, Robertson 2016, at 74.
48. See note 25, Leyser-Whalen et al. 2012, at 157.
49. See note 8, Bayefsky, Berkman 2016, at 354.
50. See note 19, Mumtaz, Levay 2017.
51. See note 19, Mumtaz, Levay 2017.
52. Biller-Andorno N. Gender imbalance in living organ donation. *Medicine, Health Care and Philosophy* 2002;5(2):199–203.
53. See note 51, Biller-Andorno 2002; Liberto H. Noxious markets versus noxious gift relationships. *Social Theory and Practice* 2013;39(2):265–87; Zimmerman D, Donnelly S, Miller J, Stewart D, Albert SE. Gender disparity in living renal transplant donation. *American Journal of Kidney Diseases* 2000;36(3):534–40.
54. See note 13, Caplan et al. 2007, at 384.
55. See note 29, Robertson 2016, at 75.
56. Raymond JG. Reproductive gifts and gift giving: The altruistic woman. In: Howell JH, Sale WF, eds. *Life Choices: A Hastings Center Introduction to Bioethics*. 2nd ed. Washington, DC: Georgetown University Press; 2000:395–406.
57. Knapton S. Infertile women could get new wombs grown from stem cells within ten years, says transplant pioneer. *The Telegraph* 2016 June 20; Hellström M, El-Akouri RR, Sihlbom C, Olsson BM, Lengqvist J, Bäckdahl H, et al. Towards the development of a bioengineered uterus: Comparison of different protocols for rat uterus decellularization. *Acta Biomaterialia* 2014;10(12):5034–42.
58. Lefkowitz A, Edwards M, Balayla J. Ethical considerations in the era of the uterine transplant: An update of the Montreal criteria for the ethical feasibility of uterine transplantation. *Fertility and Sterility* 2013;100(4):925.
59. See note 57, Lefkowitz et al. 2013, at 924.
60. Brännström M, Johannesson L, Bokström H, Kvarnström N, Mölne J, Dahm-Kähler P, et al. Live birth after transplantation of the uterus. *Molecular Cell Endocrinology* 2015;28(202):177–84.