

Form, Function, Perception, and Reception: Visual Bioethics and the Artificial Womb

Evie S. Kendal*

Swinburne University of Technology, Hawthorn, Victoria, Australia

Artificial wombs are already in development that have the potential to radically alter how we perceive the developing fetus and the role of pregnancy in society. That this technology would allow greater visibility of gestation than ever before also highlights the risk that artificial wombs will be used to further restrict women's reproductive liberty and access to abortion. This article uses Paul Lauritzen's theory of "visual bioethics" to explore the ethical significance of images of the developing fetus and how artificial wombs might best be visually designed and integrated into society.

INTRODUCTION

Much has been written lately regarding the potential impact of developments in artificial womb technology on abortion rights and beliefs about the proper boundaries of science and technology at the beginning of human life [1-4]. These accounts have focused mainly on the proposed artificial womb's function, both technical and social, and how ethico-legal systems will have to grapple with the complexities of integrating a new method of gestation into the scope of existing assisted reproductive biotechnologies. Issues of safety, for pregnant people in society, prospective parents and future offspring, dominate bioethical discussion regarding the artificial womb, with concerns that this technology may cause unforeseen damage to developing fetuses, or serve to undermine sexual equality and abortion rights for women. The potential impacts of this new technology on surrogacy or uterine transplantation are also frequently discussed [5]. What is lacking in the scholarship so far is substantive ethical

consideration of the potential form of the artificial womb, from an aesthetic perspective, and how the appearance of prototypes of this technology may impact perceptions of the artificial womb in society. This article uses Paul Lauritzen's theory of "visual bioethics" to explore this question, using analogues from the history of reproductive medicine to suggest various ways the design of this emerging technology may influence its reception.

TERMINOLOGY

There is considerable disagreement in the literature regarding the appropriate terminology to use when describing assisted gestative technologies. The term "partial ectogenesis" is often used to refer to any period of embryonic or fetal development occurring outside the organic womb, including *in vitro fertilization* (IVF) and neonatal incubation for prematurity, with "full ectogenesis" reserved for a hypothetical future scenario in which offspring are developed entirely *ex utero* [6]. The term

*To whom all correspondence should be addressed: Dr. Evie Kendal, Swinburne University of Technology, John Street, Hawthorn, Victoria, Australia; Email: ekendal@swin.edu.au.

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ectogestation has gained popularity as a method of distinguishing between existing neonatal technologies that serve the needs of infants born prematurely, and emerging technologies aimed at providing an alternative site for fetal development. At its most basic, the difference is often that the former is air-based and the latter fluid-based, but as Elseijn Kingma and Suki Finn note, what is really at stake is the physiology of the entity being gestated:

fetuses and babies have a very different physiology. Most obviously, fetuses do not breathe but oxygenate their blood via the placenta. This results in different normal arterial and venous oxygen tensions compared to neonates; requires a different kind of hemoglobin; and so on. It also necessitates a completely different cardiovascular set-up: the fetal heart functions as a single (rather than, in neonates, a double) pump; and the cardiovascular system in fetuses compared to neonates has multiple shunts, different flow rates and blood pressures in different parts of the system, and so on [6].

If birth is considered the separation of offspring from the body of their gestating parent, for Kingma and Finn, the entity in a neonatal incubator has been “born-by-location-change” as well as “born-by-physiology-change,” and thus is functioning as a neonate. Meanwhile, the entity undergoing ectogestation may have changed location, but it is still functioning as a fetus, eg, using its unique physiology, including the umbilical cord and placenta, to survive [6]. These authors suggest the term “artificial womb” is often inaccurate, proposing a shift of focus to naming the (predominantly) fetal structures that are being replaced, of which they include the amniotic cavity, claiming “artificial amnion and placenta technology” would be a more accurate label [6]. Nevertheless, the term artificial womb is retained in this article precisely because from an aesthetic perspective the three-dimensional “shell” (as some scientists working in extra-uterine gestation refer to it) that will serve as the site for gestation is the most visible element [7]. While the artificial amniotic fluid and placenta may be much more important functionally, in some designs these may be partially or entirely hidden from view, thus limiting their contribution to a visual bioethics analysis.

For the purposes of this article, the artificial womb shall refer to any assisted gestative technologies where the developing entity is physiologically functioning as a fetus but is not located inside the body of a person. This respects that fetal life is necessarily dependent on structures external to itself, which in biological pregnancy requires physical connectedness to the gestating parent, and in artificial gestation requires life sustaining technology designed for fetal physiology [8].

VISUAL BIOETHICS

In a 2008 article for the *American Journal of Bioethics*, Paul Lauritzen promotes careful consideration of “visual bioethics,” claiming images have enormous rhetorical power in ethical debate [9]. When introducing the broader “visual ethics” that preceded it, Lauritzen notes that early proponents of this theory claimed a historical privileging of “rational-linguistic approaches to controversial issues,” that focused on logical debate while ignoring the role of visual representation and emotion in resolving ethical dilemmas [9]. With a particular focus on reproductive biotechnologies, Lauritzen claims many relevant bioethical arguments have become “visually mediated,” with bioethicists “deploying” images for persuasive effect, especially those in support of granting moral status to embryos and fetuses [9]. Barbara Chubak agrees it is essential to subject visual media to ethical evaluation, claiming that images have been used to “manipulate the medical gaze” in a way that perpetuates the “devaluation and pathologization of female physiology,” including through treating male anatomy as the default and reducing representations of female bodies to just their reproductive organs [10]. Carl Senior further argues the persuasive power of images in medico-legal contexts, citing the growing use of brain scans in criminal court proceedings [11]. As juries are expected to adjudicate on the matter of *mens rea* – the guilty mind – Senior notes being able to supposedly *see* the mind of the accused, through the use of brain imaging technologies, “is so effective it can bias observers to accept nonsensical explanations” for their behavior [11]. Images can evoke strong emotional reactions of attachment or revulsion, each attending different moral intuitions. In bioethical debate, the presence of an image can serve to put a human face to an otherwise abstracted dilemma. This is particularly valuable in bioethics, as attempts to evaluate ethical principles or medical technologies in isolation from the patients they will be applied to, can sometimes lead to moral judgments that are completely decontextualized from the realities of patient care. Lauritzen provides the examples of pictures of Dax Cowart’s badly burned body as he was forced to undergo treatment, or video of coma patient Terri Schiavo’s alleged acknowledgement of her parents’ presence, as persuasive tools shaping discussions of patient autonomy [9]. For Chubak, such images contribute to “autoptic authority,” wherein one’s own experience of visual evidence is prioritized as a source of truth and legitimacy [10]. The suffering of a patient forced to undergo painful treatments against their will, is thus taken out of the realm of the hypothetical and made manifest in the image of Cowart’s flesh. This makes the image powerful, but also vulnerable to co-optation and manipulation. Lauritzen goes so far as to claim the Schiavo-

vo video “functioned rhetorically to overwhelm empirical evidence” supporting the withdrawal of life support [9]. In both cases, seeing literally was believing.

When considering the impact of visual imagery on the integration of artificial wombs into society, it is important to remember there has not previously been a way to observe fetal development directly, instead relying on ultrasound images that provide a very limited representation of the process. The rise of pregnancy tracking apps and other proximate visualizing techniques are even further abstracted. In her 2020 article for *The Guardian*, Jenny Kleeman quotes one scientist involved in artificial womb research at the Children’s Hospital of Philadelphia, stating that in the future this technology will mean “Parents can actually look at their fetus in real time” [12]. Kleeman notes the prototypes coming from this hospital and other research facilities around the world, including the Women and Infants Research Foundation in Perth, Western Australia and Tohoku University hospital in Sendai, Japan, will render the fetus more visible than ever, while working to improve the survival rates for extremely prematurely born infants [12]. But what is clear from the interviews contained in Kleeman’s article and other media accounts, is that the scientists working in this field are acutely aware of the importance of perceptions regarding this emerging technology, often distancing themselves from sensationalist accounts that liken this crucial step forward in neonatology to the many dystopian images that abound in science fictional depictions of artificial gestation. The optics matter, and the image of artificial womb research is carefully curated with scientists eager to declare their motivations lie with helping very sick infants, and not pursuing the goal of complete human ectogenesis. Nevertheless, the enhanced visibility of the fetus is likely to have a profound impact on how pregnancy and human development are viewed in society, as evidenced by previous examples of visualizing technologies, such as ultrasonography.

ULTRASONOGRAPHY AND VISUALIZING THE “FETAL ASTRONAUT”

From their earliest use in prenatal care, ultrasound images of the fetus *in utero* have been weaponized by anti-choice groups in an attempt to establish the fetus as an independent subject demanding protection. Lauritzen calls attention to the 1984 anti-abortion film, *The Silent Scream*, as a particularly potent example of this [9], although his analysis has been criticized by some for focusing more on the narration than the images he claims to be primarily interested in [13]. In reference to this film, Rosalind Petchesky notes the anti-abortion debates in the United States during the 1980s were heavily dependent on “mass culture and imagery,” drawing parallels between

the rights of infants and fetuses based solely on their visual similarities – that they “sure *look like* a baby” [14]. But as Suzanne Anker and Sarah Franklin note, just because an entity may *look* like something else, does not mean there is any moral relevance to this resemblance [15]. Petchesky notes ultrasound pictures are also inherently misleading, framed in such a way as erases the pregnant person’s body and perpetuates the myth of the “fetus as primary and autonomous” [14]. This is the only thing that makes the fetus-as-victim narrative of *The Silent Scream* possible. As Kathryn Woodward explains:

Women may be custodians of the image, but the mother’s body is absent in the representation of the seemingly disembodied foetus, floating in space, suggesting an independent person, capable of separate existence. This counters the symbiotic relationship between mother and child, which was a feature of earlier, non-visual experiences based on feeling rather than seeing [16].

Receiving an ultrasound image of the fetus is often a cultural milestone in pregnancy, with Susan Squier claiming medical tests and imaging have thus displaced “maternal testimony” as the primary method of confirming a pregnancy [17]. Reports of “feeling pregnant” or “quickening” do not have the same authority as producing a static image of a developing fetus. This goes back to the idea of autoptic authority mentioned before and the privileging of visual media over other forms of evidence. But Dion Farquhar notes this manipulated image – “the fetal astronaut” – while arising from medical technology is disseminated by popular media [18]. The result of promoting the visualization of the fetus as a separate entity in a pregnancy is the creation of a second “independent” subject whose interests can conflict with the first. A truly symbiotic relationship allows no such conflict. Likewise, a lack of fetal personhood, whether legal, moral, or both, affords no such interests.

Ultrasound images can be highly persuasive, and nothing makes this clearer than considering that jurisdictions aiming to reduce abortions mandate such images be taken and provided to those people seeking terminations of pregnancy [9]. Regina Rini, while strongly opposing such laws, nevertheless claims that engaging with such images might plausibly represent a moral obligation to be open to “moral persuasion” [19]. She notes that one US study demonstrated 98.4% of women seeking terminations of pregnancy proceeded after viewing ultrasound images, however, there was a “small but statistically significant increase in likelihood of continuing a pregnancy among women who reported medium or low certainty” of their previous choice to terminate [19]. Rini concludes: “These results therefore suggest that at least some women change their minds about seeking an abortion as a result of seeing ultrasound images,” noting this fits with

Sarah McGrath's proposal that images can serve moral deliberation by bringing about a "conversion experience" when one is faced with the visual representation of a specific "instance" of a practice [19]. For the purposes of assessing the moral permissibility of artificial gestation, it tracks that visual experience of a specific instance of this emerging technology might influence moral judgment, either for or against. This is particularly likely if the image is provoking or confronting but could also be the case for one that inspires calm or scientific fascination.

The erasure of the maternal body facilitated through the framing of ultrasound images is both a product of and in turn perpetuates the dominant Western conceptual model of pregnancy, which Kingma labels the "*fetal container model*" [6]. This model promotes the misleading view of the fetus as an independent subject, perhaps best exemplified by the rise of the field of "fetal surgery", of which Anne Drapkin Lyerly and Mary Briody Mahowald state: "the pregnant woman is referred to as the 'uterine environment,' or worse yet, as the 'recovery room' or 'natural incubator' for the fetus" [8]. Some bioethicists have noted there is currently a lack of scholarly attention paid to the moral relevance of creating an artificial womb where fetal surgery could be conducted without exposing the pregnant person to medical risk [5]. Indeed, the artificial womb is likely to make the fetus both more visible and more accessible to outside intervention. However, the appearance of this artificial womb may further fuel the idea that all gestational locations are merely fetal containers, including inside a person. Given the substantial impact the limited purview of ultrasonography has had on the abortion debate, it is reasonable to assume that without careful consideration a technology that makes the fetus even more visible might exacerbate this trend. Adopting a visual bioethics perspective to the artificial womb demands that attention be paid to how this increased visibility is managed and what design principles might best promote the interests of prospective parents and future offspring.

IMAGES OF ARTIFICIAL WOMBS IN LIFE AND ART

As noted earlier, scientists working on the artificial womb are already fighting an uphill battle of representation, with many negative images of the technology present in fiction. Kleeman's own article compares the Children's Hospital of Philadelphia project – in which a lamb fetus was artificially incubated in a sealed plastic "biobag" [20] – to the horrific images of human farms in the science fiction film, *The Matrix* (1999) [12]. The same comparisons were drawn regarding earlier work in Japan, with some media sources also throwing in quotes from Aldous Huxley's *Brave New World* (1932) for good

measure [21]. Dubbed the "ziplock lamb" online, images from the biobag research are sometimes considered confronting or distasteful. Similarly, the incubation system designed by Japanese gynecologist, Dr. Yoshinori Kuwabara's team in the early 1990s, displayed an underdeveloped goat fetus floating serenely in a tank of synthetic amniotic fluid, looking all the while *not quite right* [22]. The Perth-based *ex vivo* uterine environment experiment, also known by the acronym EVE, uses a system similar to the biobag [23], while the most recent prototype being developed at Eindhoven University of Technology in the Netherlands was announced alongside artist impressions of crimson-colored pods [24]. The design seems to intentionally resemble a disembodied uterus, while the semi-opacity prevents a view of the interior. The artwork is the sanitized version of the existing prototypes, with no half-developed animals inside that might repel the audience. Created by University of Twente designer-in-residence, Lisa Mandemaker, in collaboration with the Maxima Medical Centre and Next Nature Network, this artistic rendering of an artificial womb has garnered global attention [25]. That such a design residency exists, is evidence of awareness that the aesthetic design of the artificial womb will likely impact its reception. When asked how a prototype can "get people thinking" about emerging technologies, Lisa Mandemaker says:

The best way for me to explain that is through the example of the artificial womb. You'd be surprised how many people already have an impression of that kind of thing, perhaps from reading science fiction or watching *The Matrix*. When I tell people I'm working on an artificial womb, the reaction is often "Oh no, let's not go there!", and it becomes a very black-and-white discussion.

But when you actually produce a physical item, as a designer you have to make choices: what materials will you use, what's the purpose of the object you're making, how will people interact with it? A prototype like that invites other people to reflect on the same choices, and that's where the real discussion starts. After all, every individual sees the prototype from their own perspective: a lawyer will respond differently from a doctor or a young mother [25].

While examples of real-world images of artificial gestation are limited, there is no shortage of fictional representations. Unfortunately, many of these are dystopian future visions, often also conflating the potential social and ethical issues surrounding the advent of artificial womb technology with other possible future technologies, such as human reproductive cloning [26]. In addition to those mentioned above, the films *The Island* (2004) and *The 6th Day* (2000) contain unscrupulous scientists using artificial wombs for cloning experiments, while television series *The X-Files* (1993 –) and *Fringe* (2008-2013) include government conspiracies to create super soldiers

through ectogenesis. Books and comics also yield many examples. That media reporting on artificial womb research so frequently references such images from popular culture further demonstrates the role of representation on how new technologies are understood.

THE IMPACT OF FORM ON THE ACCEPTANCE OF ARTIFICIAL WOMBS

Whether societies will ultimately embrace, tolerate, or reject artificial womb technology will depend on many factors. One will obviously be whether the technology can be proven safe, or at the very least no more dangerous than existing interventions for premature infants. This is a question of functionality. Given the poor prognosis of extremely prematurely born infants at present, it is likely any chance of survival might meet the threshold for support for these infants. Full ectogenesis is a different equation, however, early successes in neonatal use will supply evidence of efficacy that could in the future satisfy these safety standards as well. Another factor influencing potential social dis/approbation for this technology is the question of form – in other words, how the technology looks impacting how it is treated. If the public are repulsed by images of artificial gestation, or associate the technology with negative fictional representations, this may hinder uptake and acceptance. In his article, “The Wisdom of Repugnance,” Leon Kass claims feelings of disgust can often stand in for moral intuitions we are unable to articulate [27]. By this logic, if people feel uncomfortable looking at images of lamb or goat fetuses gestating outside their mothers’ wombs, this might suggest there is something morally wrong with bringing this situation about. However, such intuitions are not ethical arguments in their own right, and it is important to remember that cultural values can change to incorporate lifestyles and technologies previously considered unacceptable. It is also relevant to consider that it is not just that the design of artificial womb prototypes will likely influence public perception of the technology, but also that these existing societal views, mediated through visual images, will likely exert influence on the design process. For example, designers may actively avoid any resemblance to pods from *The Matrix* in order to avoid triggering what Kass refers to as the “yuck factor” [27]. A visual bioethics approach can account for this phenomenon as well.

The increased visibility of fetal development also has ramifications for parental bonding and abortion rights. It might end up being the case that artificial wombs are not as useful for the anti-choice campaigners as ultrasonography was, precisely because they would allow greater visualization of earlier stages of development where the fetus does not look like a baby. However, it is perhaps more likely that the existence of artificial wombs will em-

bolden those who wish to further curtail abortion rights in some jurisdictions around the world, as they would then be able to point to exactly what kind of entity was being destroyed. Claire Horn argues that the focus of much of the current bioethics scholarship on artificial wombs is misplaced, assuming a severance theory approach to a situation that has significantly changed since that theory was proposed [28]. According to severance theory, the termination of the life of the fetus during an abortion is only permissible because it is an unavoidable side effect of a woman’s right to bodily autonomy. Proponents of this theory suggest once an alternative to fetal destruction is possible, such a moral allowance would be rendered null and void – the developing fetus could then be transferred to an artificial womb while still preserving the rights of pregnant people to terminate the dependence of the fetus on their own body for survival. Horn claims this account is “hopelessly anachronistic” though, as the surgical intervention required to transfer a fetus into an artificial womb, while similar to early forms of abortion, is dramatically different to the more common methods used now, such as taking oral abortifacients [28]. Thus, using the advent of artificial wombs to require women to have their pregnancies transferred rather than medically terminated, would mean forcing women to remain pregnant until the fetus is old enough to be transferred and undergo a major surgical intervention when they would otherwise simply be able to take medication early in gestation to achieve a termination [28]. A relevant contribution the increased visibility of fetal development might have here is dispelling myths that ectopic pregnancies can be transferred into the patient’s uterus, a procedure which is medically impossible and yet still legally debated [29]. Similar practical constraints prevent the transfer of early pregnancies from one biological uterus to another.

When it comes to parental bonding with artificially gestated offspring, the quote included earlier about parents being able to view their fetus developing in real time seems to suggest such an opportunity would be expected to enhance bonding. However, there is a risk parents will feel repulsed by the image of a very non-baby-looking fetus, potentially leading to feelings of inadequacy and guilt. Parents of infants in neonatal intensive care units often describe feeling constantly “on duty” and obliged to be close to their infant as they struggle for survival [30]. The same is likely to occur for parents of extremely premature infants placed in artificial wombs in the future, except potentially for even longer periods of time. Imagining a scenario where full ectogenesis has been achieved, there is also the risk this feeling will attach to the entire gestational period, leading to significant stress. Other studies show parents whose infants need artificial incubation after birth report feeling guilty, powerless, alienated from the care of their child, and detached from

the process of parenting due to the feeling they have to request permission from nursing staff to interact with their infant [30-32]. So, while some parents may enjoy being able to watch their fetus develop in “real time” others may find this experience distressing or alienating. This suggests there might be an ethical obligation to investigate the impact of limiting viewing access to artificial wombs if evidence arises that this would prevent damage to parental bonding or mental health.

ETHICS OF DESIGN FOR THE ARTIFICIAL WOMB

Paying attention to the aesthetics of the artificial womb is important for successfully integrating it into society, avoiding its co-optation by anti-choice interests, and preventing a situation where parents are made uncomfortable by images of early fetal development they may find personally confronting. Most of the prototypes being developed at present assume reduced lighting or dark, enclosed systems will best mimic the conditions of the biological womb, but this might interfere with some users’ desires for greater visibility. It is likely some parents will prefer an occluded or partially-occluded system, while others will prefer a highly interactive experience, with pregnancy milestones like the first ultrasound image being replaced by *ex utero* alternatives. We can even imagine a scenario in which so-called “gender reveals” are conducted around a womb tank. For such events, an appropriate user interface will be necessary that balances parental desire with protection for their well-being and that of their future offspring.

Design ethics refers to the practice of incorporating ethical values into product and visual design. According to Peter-Paul Verbeek, this process involves being conscious of the “social impact that the technology in design will have as soon as it enters society” [33]. If the goal is to capitalize on the positives of artificial womb technology, in terms of promoting premature infant survival, expanding reproductive choices, and enhancing the gestational and parenting experience, while simultaneously avoiding any threat to abortion rights or the risk of social rejection of the technology, this requires careful consideration of how the system should look, who should have access to view it, and whether there are grounds to limit exposure to this new visualizing technology to protect the health and well-being of prospective parents. Something as simple as whether the system should be designed with a curtain that allows parents a chance to prepare before viewing their developing fetus has both functional and ethical dimensions. Given the significant influence of visual media on how reproductive biotechnologies are treated and understood, this suggests the need for detailed analysis of emerging artificial womb designs from a visual bioethics

perspective.

Such an approach would consider not only the visual aspects of the technology itself, but also its various artistic renderings in society. It would evaluate prospective designs in light of their appearance, the proposed design materials, and the accessibility/visibility of various components and the developing fetus. It would consider how to avoid perpetuating the image of the fetal astronaut and the fetal container model of pregnancy, that can damage the interests of pregnant people, and be cognizant of the impact of this emerging technology on ethico-social views of abortion, fetal surgery, and the moral status of the human embryo or fetus. It is also important to consider that the form the artificial womb takes may serve to highlight certain ethical issues while obscuring others, and that the design optics are morally relevant considerations when promoting this technology.

More speculatively, the form of the artificial womb may yield additional ethical questions that have not been relevant for gestation before. For example, do prospective parents have the right to control who views their developing fetus? Should there be consideration of the future child’s privacy when it comes to the visibility of their fetal development, and if so, when would this consideration take effect: At implantation? When their external genitalia are discernible? Only after they are disconnected from the system? Would prospective parents seeking to terminate an artificial pregnancy be required in some jurisdictions to visit their developing fetus in an analogous way to those seeking abortions who must be provided ultrasound images? Is there a moral obligation to promote the artificial womb design that best mimics the organic womb in terms of exposure to light, sound, temperature, etc.? Is outward appearance relevant here too? Will visual discomfort be grounds for conscientious objection for health providers wishing to avoid working with ectogenetic fetuses? These questions illustrate just some of the ethical issues that will attend the form of this emerging technology.

CONCLUSIONS AND OUTLOOK

Artificial wombs are already in development that have the potential to radically alter how we perceive the developing fetus and the role of pregnancy in society. That this technology would allow greater visibility of gestation than ever before also highlights the risk that artificial wombs will be used to further restrict women’s reproductive liberty and access to abortion. However, with careful consideration that takes into account the rhetorical power of visualizing technologies, ethical issues surrounding the form and function of this new technology can be addressed before its release into society. There is a need for future studies that look at the impact of images

of very early fetal development on parental bonding and the role of ethical design in prototyping this emerging technology. The theory of visual bioethics combined with design ethics provides a useful starting point for this exploration.

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