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The Strange Case of the Artificial Placenta: The Harms of Depicting Ethical Challenges as Existential Threats

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Abstract: While most ethical reflection on new technology focuses on their disruptiveness, I will use the example of artificial placentas (APs) to discuss the opposite risk: Overblowing the potential disruptiveness of new health technologies. To do so, I will first explain why AP is regarded as disruptive and why it is not. Second, I will explain the risks of overblowing AP disruptiveness's. Finally, I will discuss how to better manage AP challenges. AP is a technology meant to improve the survival and quality of life of preterm infants. Many regard the AP as a disruptive technology for three reasons: 1) AP will create a new moral entity, 2) AP is an innovative technology that might disrupt treatment of preterm, and 3) even lead to an artificial womb. Although challenging, AP will not be disruptive and framing it as such can be harmful. For example, it is technically impossible to derive an artificial womb from the AP. Insinuating that one will lead to the other might generate public's rejection toward AP and halt or delay research, harming preterm infants who could benefit from the AP. Overemphasizing unlikely scenarios is also leading to overlook the more concrete and urgent ethical challenges concerning trial and implementation.

Keywords: artificial placenta; ectogestation; extremely preterm infants; neonatal intensive care; reproductive technologies; disruptive technologies

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1. Introduction

Artificial placentas (AP) are technologies that mimic the conditions and functions of the human placenta in order to achieve better chances of survival and good quality of life specifically for extremely preterm infants (Alice Cavolo, de Boer, De Proost, Verweij, & Gastmans, 2024). Extremely preterm infants (EPIs) are infants born below 26 weeks of gestation as compared to the 40 weeks of a normal pregnancy (Blencowe et al., 2013). Due to their physiological immaturity, and especially due to their lung immaturity, EPIs still face high mortality rates, with only 20% to 50% infants surviving between 22 and 25 weeks (Myrhaug, Brurberg, Hov, & Markestad, 2019). Importantly, currently available care is only partially successful for this specific population given the high mortality rates. Even when successful it often results in short- and long-term complications associated with mechanical ventilation itself (Bird, 2017; Myrhaug et al., 2019). Hence, the need for a more efficient treatment for these infants.

The first attempts to develop an AP for treatment of EPIs occurred in the 50s and in the 90s but were unsuccessful due to the lack of technological advancement that lead to ahigh mortality in the animal trial.(Bulletti, Sciorio, Palagiano, & Bulletti, 2023) It is relevant to note, however, that already at the time, these first attempts sparked ethical discussion on the ethical acceptability and potential ethical and societal impacts of such a technology, not only for treatment of EPIs but also for potential uses beyond its medical use.(Cannold, 1995; Humber, 1977; Overall, 1993)

Recently, new attempts have been made to achieve an AP. Several research teams are currently developing an AP prototype and testing it on animals. The team at the Children's Hospital of Philadelphia (USA) announced in 2017 that their AP, the EXTra-uterine Environment for Neonatal Development (EXTEND), sustained lambs for four weeks.(Partridge et al., 2017) EXTEND consists of a sealed bag filled with synthetic amniotic fluid in which the EPI is placed. A closed circuit of catheters imitates the umbilical cord to provide water and nutrients, and to expel waste. An external

oxygenator ensures oxygen provision.(Flake, 2022; Partridge et al., 2017) A joint effort of the Tohoku University (Japan) and the University of Western Australia is developing a similar technology, the Ex-Vivo Uterine Environment (EVE).(Usuda et al., 2017; Usuda et al., 2019) A third group in the University of Michigan is researching a pump-driven system, in which the blood circulation is maintained by an external pump instead of the EPI's heart.(Usuda et al., 2021) More recently a Dutch and a Spanish team announced that they are developing an artificial placenta.(Zimmer, 2021)

Similar to what already happened in the past, the announcement of a (successful) AP trial sparked a rich ethical discussion. In particular, some authors(De Bie, Kim, et al., 2023; Segers, 2021) warned that AP will completely change (or disrupt) the status quo of the neonatal intensive care, both in terms of the care provided and of the social relations. As this corresponds exactly to Hopster's definition of a "new disruptive technology", it is fair to say that these authors regard AP as disruptive regardless of whether they explicitly use this term (Hopster, 2021). A systematic argument-based review revealed that many regarded the AP as a disruptive technology for three main reasons.(Alice Cavolo et al., 2024) First, AP will generate a new moral entity; second, AP is an innovative technology that will disrupt treatment of EPIs; and third, AP will lead to an artificial womb, i.e. a technology able to maintain an entire gestation outside the human womb. Although these authors never make the claim that AP will pose an existential threat, this could be inferred from how they describe AP and its potential. Importantly, AP will not be an existential threat in the literal sense that it might hinder human existence but in the more philosophical sense of putting in question our conceptions what we consider "to be human", e.g. by generating a new moral entity or in the risk that AP might lead to an artificial womb decoupling, in this way, reproduction from human beings. Similarly, AP could pose an existential threat by radically changing our social dynamics, again in the case of an artificial womb, or what some consider our essential rights as human beings, e.g. if AP will affect abortion rights.

Contrary to these authors, I argue that AP, although challenging, will not be disruptive nor an existential threat, and that framing it as such can be harmful. For example, it is technically impossible to derive an artificial womb from the AP. Insinuating that one will lead to the other might generate public's rejection toward AP and halt or delay research, harming EPIs who could benefit from the AP. Overemphasizing unlikely scenarios is also leading to overlook the more concrete and urgent ethical challenges concerning trial and implementation. Therefore, in this article, I will first explain why AP is regarded as disruptive and why this would lead to an existential threat. I will also explain why this is not the case. Second, I will explain the risks of overblowing AP's disruptiveness. Finally, I will briefly discuss how to better address the challenges of APs and other innovative, but not disruptive, technologies.

2. Why AP is considered an existential threat and why it is not

Artificial placentas (AP) are considered an existential threat for three main reasons: 1) they will generate a new moral entity; 2) they will disrupt neonatal intensive care; and 3) they will ultimately lead to artificial wombs. I will now present and discuss each of these arguments in-depth.

2.1. AP will generate a new moral entity

The first reason why some believe that APs will pose an existential threat is that they are believed to create a new moral and legal entity somewhat between a fetus and an infant, i.e. with more rights than a fetus but less than an infant (Kingma, 2021; Kingma & Finn, 2020; Romanis, 2019, 2020a, 2023).

The most convincing argument for believing that the AP subject is a new moral entity is that the AP subject is not completely born. According to Romanis and Kingma and Finn being born implies a change of location from the womb to the external environment as well as a change of physiology, including inflation of the lungs.(Kingma & Finn, 2020; Romanis, 2018, 2019, 2020a) While AP subject is geographically born, as it was extracted from the womb, it is not physiologically born as the lungs did not inflate. Others maintained that the AP subject is born because the conventional clinical definition of birth requires evidence of life, such as breath or heartbeat, however supported. AP subjects have a heartbeat, which is a necessary condition for most APs to function. Hence, the AP subject is born and, as such is an infant.(Colgrove, 2019, 2020, 2022; Rodger, Colgrove, & Blackshaw, 2021)

I believe that these two positions and the sources that substantiate them reveal a crucial difference between the legal and clinical perspective on birth in general, and subjects in APs in particular.

Those with a legal perspective, elicit the need to clearly categorize the legal entity as, depending on the specific legal status, different rights and duties are attached. For example, as Romains pointed out, in the English legal system pregnant people cannot be charged with fetal endangerment since the fetus has no legal status but a woman can be charged for endangering a child since a child has full legal status.(Romanis, 2020b) I am aware that this is not the case in all jurisdictions and that in some countries pregnant persons can and have been charged for fetal endangerment.(Horn, 2020b) Nonetheless, this shows the need for clear categories within the legal system as depending on how AP subjects are defined drastically different rules apply. Further, regardless of the clinical definition some legal jurisdictions specifically mention drawing the first breath as a necessary criterion to establish whether a live birth occurred.(Romanis, 2020b, 2020c) In that sense, I agree with Romanis that AP will create a unique legal entity that has currently no legal protection.

However, the simple fact that a new legal category is born, pun intended, does not mean that the technology will be disruptive and that will result in a new moral category. It is worth noting that these articles mainly show the need for a new category, and with it, new rules as well as defining said category. To my knowledge no specific attempt to draft these new rules was made. It might be the case that establishing new rules for this population will not be exceptionally difficult or disruptive. Even if it will be disruptive, their impact is going to be more limited than these authors predicted as these new categories/rules will affect only a tiny subset of the population: AP subjects for whom it was necessary resorting to the court. Currently, court cases for treatment decisions at birth of EPIs are extraordinarily rare and there is no reason to believe that this will change once APs will be available. To the opposite, the clinical perspective is mainly concerned with understanding how to care for the patient. To this regard, the legal status is only partially relevant. For example, some jurisdictions allow funerals for miscarried fetuses acknowledging that, although the fetus is not legally a person, some parents already perceive it as "their child" and might need the funeral for the bereavement process.(De Proost & Zuijdwegt, 2023) When we look at the AP context, we must consider that at the moment in many countries parents still have the choice to not resuscitate at 23-25 weeks,(Guillén et al., 2015) meaning that choosing AP implies choosing active treatment. From a clinical deontology point of view, active treatment qualifies the AP subject as a patient, meaning that healthcare providers will have the same duties and obligations that they have for other patients.(Mercurio, 2018) Further, we already know that parents choosing active treatment tend to consider the infant "their child" and suffer when the care team treat the child as anything less, for example using the term fetus and not using the child given name.(Alice Cavolo & Daniel Pizzolato, 2024) It is not difficult to imagine that parents who will choose AP might be equally hurt by terms like "gestateling"(Romanis, 2018) or "fetonate"(De Bie, Kim, et al., 2023) that have been introduced to identify AP subjects. This, in turn, means that, regardless of the legal status, from a relational and clinical point of view, AP will not substantially change things in daily operations of the neonatal intensive care unit, as AP subjects will likely be treated as any other infant or patient in the ward. A case could be made that AP might be disruptive at least in countries where parents cannot choose whether to resuscitate due to lack of resources or due to guidelines requiring to always resuscitate. However, also in this case AP will not affect the status quo. Countries that do not have the resources to support these infants will likely not have the capital needed to invest in APs, which is a problem in and of itself but a different one, and countries with more proactive regulations will remain so.

The other arguments to explain why the AP subject is a new moral entity are less convincing. The second argument maintains that AP subjects are new moral entities is that they have no capacity to live independently because, while infants have independent capacity for life thanks to the physiological change, AP subjects completely depends on the AP.(Romanis, 2018, 2019, 2020a) However, as others already explained, AP subjects have some independent capacity to live independently because for AP to work the subject must be sufficiently developed to survive the transfer, to be cannulated, and to maintain circulation as the majority of AP prototypes are powered by the subject's heart.(Wozniak & Fernandes, 2021) Further, I agree with Wozniak and Fernandes (2021) that independency is not a convincing argument as all neonates depend on adults' care to survive.

The last argument to support the thesis that AP will create a new moral entity is that the AP subject is completely separated from the external environment as compared to a fetus, who is inside the pregnant person's body, and to an infant, who has direct contact with the parents (and the care team).(Romanis, 2018, 2019, 2020a) However, this argument does not take into account the efforts of the developers to work with parents to find solutions to allow some interactions with the child, for example by having opaque APs that allow for visual contact, or by allowing the AP subject to hear the parents' voices.(Verweij et al., 2021) It also does not take into account the reality of

neonatal intensive care where direct contact with EPIs is often denied or minimized to ensure the child's safety, which brings us directly to the next point.

If AP truly generates a new moral entity, then it might pose an existential threat in the sense that it might disrupt our conception of what makes a human being, what it means to "be born", and our relations with it. However, as we saw, at most AP generates a new legal category but it will not disrupt our moral conceptions or relations.

2.2. AP is so innovative to disrupt care for extremely preterm infants

The second reason why some believe that AP will constitute an existential threat is that AP is an innovative technology different from all other technologies currently in use in neonatal intensive care and that consequently it will severely affect the care provided to EPIs as well as parent-child relationships.(Romanis, 2018; Romanis, 2019; Romanis, 2020; Segers, 2021; Segers and Romanis, 2022; Cohen, 2017; Romanis and Adkins, 2023) This is true to an extent but largely overestimated.

When we focus, as these authors do, on the technology itself, this is true. All AP technologies currently under development are technically very different from available technologies. In that sense, AP is, without a doubt, an innovative technology. However, AP will not disrupt the status quo, be it the care provided, social relations or dynamic, etc

What these authors fail to consider is that, although the technology itself is innovative, its effects are far from revolutionary. First of all, AP has the same goal of currently used incubators and treatments in neonatal intensive care, i.e., to mimic the conditions occurring in the human womb to improve survival and reduce morbidity in EPIs.(Colgrove, 2019; Wozniak & Fernandes, 2021) APs are simply expected to be more effective in doing so than current neonatal intensive care is. Second, although AP is expected to provide a better treatment to address the underdevelopment of the lungs for EPIs, it will not substitute intensive care as a whole rather, it will be one of the treatment options within neonatal intensive care.(A. Cavolo, 2024) EPIs in AP will still be at high risk of a variety of complications that will require a variety of different intervention spanning from pharmaceutical intervention to surgery.(De Bie, Davey, Larson, Deprest, & Flake, 2021) In other terms, AP will change only one aspect of the complex care needed to support these infants; neonatal intensive care as a whole will largely remain the same. Third, some postulate that AP might target more infants than neonatal intensive care because it might lower the viability threshold, i.e., the week of gestation at which the infant can potentially survive, and care might be provided.(Browne, Kendal, & Sudenkaarne, 2023; Horn, 2020a; Romanis & Horn, 2020) However, in the foreseeable future, AP will not alter the viability threshold. As previously mentioned, the circulatory system needs to be sufficiently developed to sustain the AP, which normally occurs at 22/23 weeks that is the current viability threshold. In other terms, AP will target the same population that is already treated with conventional neonatal intensive care. Even assuming that AP will lower the viability threshold, there is no reason to believe that this will be disruptive. After all, we have been steadily lowering the limit of viability for many decades constantly adapting our ethical considerations to the everchanging medical landscape.(Lantos, 2018) Similarly, if AP will result in an increased number of preterm infants to be treated, this would affect the intensive care and it would be challenging for the healthcare system but it will not pose an existential threat. Again, this is a challenge that clinicians overcame every time we lowered the limit of viability. To be clear, I am not pretending that the decision-making for treatment of EPIs is easy of free from ethical challenges, as this is an extremely complex and challenging scenario for parents and clinicians alike. What I am saying is that AP will not substantially change it for the worse nor for the better.

AP's impact on parents-infant relationship is also, in my opinion, overestimated. For example, according to Romanis and Adkins (2023) APs might increase sentiments of pregnancy-loss following a preterm delivery as well as hinder parent-infant bonding due to the lack of direct contact with the infant in AP. I agree that pregnancy-loss feelings might occur, and that care should address and as much as possible prevent these feelings. However, as Romanis and Adkins elicited pregnancy-loss feelings are already common in preterm deliveries (Romanis & Adkins, 2023), indicating that this is a risk for all preterm deliveries regardless of if and how the infant is treated after birth. Similarly, parents already suffer due to necessary and often long separations from their infant in the neonatal intensive care unit. Further, I already explained that, although it is true that direct contact will likely not be feasible with an infant in AP, some forms of indirect contacts will likely be possible. Hence, AP surely raises similar challenges for parents (and the healthcare providers that should address them) as current neonatal intensive care but there is no indication that it will substantially worsen them.

Once we established that AP will not disrupt or even substantially change neonatal intensive care, a better question to determine whether AP could be a disruptive technology would be: will AP have a ripple effect on other areas of care? For example, some proposed that AP could be used electively by parents for several reasons, including avoiding pregnancy ailments (e.g., nausea), pregnancy limitations (e.g., abstaining from alcohol), or being more competitive on the job market by reducing maternity leave duration.(Holmes & Hosford, 2023; Nelson, 2022) However, the capacities of APs are still rather limited. As previously explained, APs will sustain the fetus lungs for few weeks outside of the womb until they are strong enough to support intensive care, but they will not solve all prematurity issues meaning that these infants are still exposed to high mortality and morbidity risks. Hence, a scenario that allows to deliver infant so early and expose them to the risks of extreme prematurity without a serious medical reason is unlikely. After all, we are already able to treat infants born as early as 27 weeks with excellent results,(Myrhaug et al., 2019) but pregnant people are still not allowed to electively choose preterm delivery without medical reason as the risks are still substantial. Similarly, other uses of AP will therefore be likely limited to other high risks situations, such as maternal-fetal surgery, as it is expected to be less risky for the pregnant person and the fetus if the surgery is conducted in AP rather than in utero, or when the pregnant person is at life-risk and their treatment conflicts with fetal safety like in cancer patients.(Partridge et al., 2017)

2.3. AP will ultimately lead to an artificial womb

The third reason why some believe that AP will pose an existential threat is that it will ultimately be or lead to an artificial womb, i.e. a futuristic and currently unobtainable technology able to maintain an entire gestation from conception to extraction in an artificial environment. Should that be true, then AP might pose an existential threat, if not now at least in the future. Decoupling gestation and human being might seriously alter our moral intuitions about what it means to be human or to be born, as well as it could completely change our social relations. Compared to the other statements, this third argument is never explicitly made. However, when we analyze these authors' argumentations, we can see that there is either confusion between the two technologies or the underlining idea that one will ultimately lead to the other.

This is clear when we consider the debate on the social implications of AP. For example, Holmes and Hosford (2023) argued that pregnant persons should be allowed to choose AP to further their education or their career.(Holmes & Hosford, 2023) The idea being that by reducing the pregnancy period, pregnant people can invest more time in their studies and career and be more competitive on the job market. This type of arguments is misleading as it gives the impression that you can place an infant in an AP worry-free and go on with your life for another few months. The reality of neonatal intensive care could not be farther from that. These infants are at constant life-risk and their parents are required to make countless medical decisions for them. Parents are also actively involved in their infant care as much as possible. Further, these infants are more likely than infants born at term to suffer from a variety of conditions and impairments because of prematurity or intensive care. Even when they do not, EPIs will need more frequent follow-ups in the first years than term-infants. Hence, unless parents opt for adoption, these EPIs require much more care and attention than term-infant, hindering rather than enabling parents' complete focus on their careers.

Even assuming that AP would be completely safe and would allow to gestate an infant until the end, it will not bring the social benefits that these authors suggest. What often goes amiss is that the bulk of maternity leave is normally taken after pregnancy as even a healthy neonate requires constant care, which is currently still mostly provided by women. Hence, social changes like introducing paternity leave and a better division of childcare among partners, although less technological as a solution, will probably be more effective and revolutionary for the society and people's daily lives than allowing an elective use of AP.

Other scholars warn that AP might increase social inequalities, for example if access will be limited to traditional family units as it is the case for IVF in some countries.(Horn, 2020a, 2022; Kimberly & Quinn, 2023; Roesner, 2023; Romanis & Horn, 2020) This again gives the impression that AP could serve as a reproductive option, while in reality AP cannot support conception or the embryonal phase. One might imagine that by miniaturizing the AP system, or by improving it, we could ultimately achieve an artificial womb. However, it is technically impossible to derive an artificial womb from an artificial placenta, as supporting the complex processes that occur in the womb, especially in the first trimester of the pregnancy, requires more than simply miniaturizing the AP technology. That is not to say that we will never achieve an artificial womb, but to do so we

will need to design a new technology from the get-go. Hence, AP cannot be considered as the first step toward an artificial womb.

This underlining misconception between AP and artificial womb is even more evident when we consider the abortion debate, which is also the only instance in which I agree that AP might pose an existential threat as it might erode our reproductive rights. Some proposed to use APs as an alternative to abortion.(Kaczor, 2005; Simkulet, 2020; Stratman, 2023) Their thesis is that AP will allow a pregnant person to terminate a pregnancy without terminating the fetus as well. In this way, they say, the pregnant person's right to respect for autonomy and a fetus' right to life are both respected. Some hypothesized that AP could also increase pregnant persons' reproductive choices in countries where abortion is banned, as it would introduce at least a possibility to interrupt the pregnancy.(Cohen, 2017; Yaakob, 2022) Once again, this line of argumentation ignores the reality of APs in development. The authors give the impression, or assume, that AP will be as safe for the pregnant person as abortion is, and that it is safe for the fetus/future child. That is because the underlining assumption of their arguments is that AP could be employed at any stage of pregnancy and that the infant could be gestated in AP for an indeterminate period of time.

However, the reader will know by now that AP can only be used for a few weeks starting from 22-23 weeks of gestation and that APs require a C-section or a vaginal birth. Both are riskier for the pregnant person than any form of abortion currently available.(Romanis & Horn, 2020) Hence, from a clinical point of view, AP would require the pregnant person to undergo a much riskier procedure. From an ethical point of view, using AP as a compulsory alternative to abortion would require pregnant persons to stay pregnant longer than they desire and to undergo an invasive and unwanted procedure, all of which is against medical deontology.(World Medical Association) The belief that AP would be safe for the fetus is also questionable because AP is an invasive and high-risk procedure conducted on a vulnerable infant who might die in the highly medicalized environment of the intensive care potentially alone, as the biological parent(s) opted for abortion. On top of that, we also need to account for the risks of prematurity. Some might say that any life, regardless of the length or quality is better than no life, but at the very minimum we need to be honest about the implications of AP. Further, AP, like any innovative technology, will be an expensive and rare resource. Sure, we can expect that in time, it will be cheaper and more widespread, as this was the life progress of many medical technologies from incubators to dialysis. However, neonatal intensive care is, and will remain, a very expensive and specialized form of care, as proven by the fact that it is already not available in every hospital, and many regions and countries cannot offer widespread access to this care due to its cost.(World Health Organization, 2023) This will be true with or without AP. Redirecting APs from families who made an active treatment choice for a wanted pregnancy, and from infants for whom it could be a life-saving treatment, to forcibly impose it onto people who do not want to be pregnant/parents and who have a safer, more effective, and cheaper alternative to achieve that, is not only unethical but also an unfair use of resources. All that to say that, although I agree that there is a risk that termination of pregnancy followed by AP will be employed as to the only possible form of abortion and that used this way AP would be disruptive and an existential threat, this should not be the case as medically and ethically there is very little justification to do so.

I do believe that one of the reasons why this is a risk is that in advocating using AP instead of abortion, scholars are not realistic about the actual capacity of the technology nor honest about the real implications of such a choice for pregnant people and for EPIs and their families, which are often invisible in this particular debate as if this use of AP would not affect them as well. Instead, they propose an idealistic risk-free solution that resemble more a futuristic, and currently unobtainable technology, rather than the actual technology that we have.

3. Why is treating AP as an existential threat problematic?

In the previous section we discussed at length why AP will not be an existential threat for the most part. In this section we will discuss why regarding it as such is problematic, if not even harmful. This might sound too hard of a statement. After all, one might say that it is better to be overly prepared for the worst-case scenario, even if it will not eventually happen, rather than being under prepared. This is only partially true as overblowing the potential of innovative medical technologies has real consequences that should be accounted for.

3.1. Overblowing the (negative) potential of AP might affect the public's perception of AP and its implementation

The first problem is that overblowing the negative potential of AP can generate so much distrust in the public that research can be halted and, consequently the development and provision of better care for EPIs could be delayed. We must be aware that, whether we like it or not, the public's opinion on given innovations does matter and we already experienced cases in which a technology was halted due to public mistrust. For example, implementation of genetically modified organisms (GMO) in Europe has been restricted due to people's fear of potential health risks of using GMOs. This regardless of scientists' reassurances about their safety.(Lee, 2009) Further, even if public's mistrust will not halt research per se, it might still halt implementation. If parents do not trust the technology, they might refuse it regardless of its potential benefits. Hence, the risk that public's mistrust on AP could halt research should be taken seriously and, as much as possible, prevented. To be clear again, I am not against the idea that research on AP, or even its later implementation, could be suspended due to people dislike of the technology. However, such a decision should be based on an honest debate rooted on facts and stakeholders' opinions, not on fear mongering.

Especially concerning, to this regard, is the confusion between AP and artificial wombs. As Kendal (2022) explained, artificial wombs have been a constant element in many popular dystopias from Aldus Huxley's Brave new world to the Wachowski's The matrix.(Kendal, 2022) Importantly, the idea of artificially gestating human beings has always been depicted negatively in these fictions. Confusing AP with artificial wombs or giving the idea that one will inevitably lead to the other, might affect people's perceptions and acceptance of AP. Already in 1995, Cannold's empirical study on artificial wombs elicited that women disagree with using artificial wombs to substitute pregnancy, so to speak.(Cannold, 1995) Preliminary discussions I had with parents of EPIs who spent months in neonatal intensive care units seem to confirm, although anecdotally, Cannold's result. These parents did not seem to be particularly concerned with the look of AP or the lack of contact with the infant inside the AP, as one might expect. They were worried that AP could represent a first step to achieve a "test-tube baby", in the word of one of these parents. In line with my own concerns about the effects of speculating about artificial wombs and unrealistic AP uses, AP developers have expressed concerns that such speculating could result in hindering the development of AP.(De Bie, Flake, & Feudtner, 2023) For similar reasons, Verweij et al. (2021) proposed to use the term "artificial placenta and amnion technology" rather than "artificial womb" to avoid confusion between the two technologies.(Verweij et al., 2021) In fact, the choice of the term "artificial placenta" in this article, and in all my articles on the topic, was intentional and one of the reasons was to differentiate current technologies developed for treatment of EPIs and other at-risk infants from an artificial womb. Further, overblowing the negative impacts of an innovative technology might not only undermine the public's or patients' trust, but also impede finding appropriate solutions to address challenges faced by the patients. Let's go back to the example of increase of pregnancy-loss feelings in preterm deliveries. As I already argued elsewhere,(A. Cavolo, 2024) misplacing this risk as a direct consequence of the technology, rather than a consequence of the situation could firstly lead parents and healthcare professionals to refuse the technology for fear of a risk that might occur anyway. This might harm those parents and infants who could have benefitted from AP. Secondly, it could impede finding an appropriate solution to address pregnancy-loss because we are not addressing the actual root cause of the problem.

When it comes to AP, we saw that most of the ethical literature tends to overemphasize the negative potential rather than the positive. However, it is important to underline that the opposite scenario, i.e. overblowing the positive potential of AP would be equally problematic. For example, narrative that overly emphasizes AP successes in improving quality of life and/or survival might lead parents to have unrealistic expectations on AP's capacity. Should the patient die, distrust in the care team might lead the family to develop long-lasting doubts, regrets, distress, and potentially to sue the hospital.(De Proost et al., 2021) In the long-term, distrust might also lead people to refuse future (innovative) beneficial treatment due to a previous unmet expectation that might have tainted the trust in the healthcare system as a whole.

3.2. Lack of nuances might lead to inappropriate solutions

Lack of nuances in the discussion of the risks of a technology might lead to black and white solutions rather than a more nuanced approach that adapts potential solutions based on each specific actual or potential use of the technology. For example, because of the potential threats to reproductive rights, some seemed to advocate against APs to prevent the harms that might result from using it beyond its medical intended scope.(Adkins, 2021; Hooton & Romanis, 2022; Romanis, 2018, 2020a) Although the risk is it does not warrant banning AP altogether, considering that AP does not pose an existential threat if used for its intended purpose and in its intended context,. Rather, we should discriminate between legitimate uses of the technology, and

illegitimate, or misuses, of the same technology. In other terms, we should ban misuses of the technology, not the technology itself.

3.3. Focusing on hypothetical scenarios might lead to overlook short-term challenges

Focusing on hypothetical challenges of a hypothetical non-existing technology or of hypothetical new uses of an existing technology might distract from the actual challenges of the current technology in its current uses. When it comes to AP, this is already happening. Taking a step back, AP is not a disruptive technology, but it is an innovative technology and, as all innovative technologies, it will raise important challenges at the clinical trial and implementation level. Despite that, little attention has been paid to AP challenges in the trial and implementation phases. In a previous systematic review of articles on APs we found that most articles discussed the moral status of the AP subject or AP's ethical implications for abortion and reproductive rights in general. Only 12 out of 45 eligible articles discussed the clinical-ethical implications for the AP trial and implementation specifically for EPIs.(Alice Cavolo et al., 2024) This already shows how short-term concrete challenges of AP are critically understudied compared to long-term challenges and hypothetical new uses of the technology.

How these articles discuss clinical-ethical issues of AP is also partially problematic. Most of these articles only provide generic advice that is valid for all clinical trials, such as the need to obtain a true informed consent through proper counselling, but there is not much research on how to address the unique challenges of AP trial and implementation.(Alice Cavolo et al., 2024) For example, much more pressing questions for AP are: How do we identify the challenges of a technology that is not even fully developed yet? What are the ethical challenges of trial and implementation? How do we address them? The fact that we are regarding AP as something completely new that has nothing to do with the previous treatment for EPIs is part of the reason why these questions are still unaddressed. After all, if AP is completely new, how can we foresee its ethical issues and its potential solutions beforehand? However, although the AP is technically innovative, its goal and the context of its application are not. For example, when it comes to the clinical trial, the AP trial will share many relevant characteristics with other maternal-fetal surgery trials, particularly the fact that it targets fetal physiology so it will be conducted directly on the interested vulnerable population and that it will require a surgery on the pregnant person's body for fetal benefit. Indeed, looking at the similarities between maternal fetal surgery trials and AP trials, we identified many potential challenges that are still unaddressed.(A. Cavolo, Gastmans, & Crombag, 2024; Alice Cavolo & Daniel Pizzolato, 2024) For example, one expected major issue are difficulties in recruiting and retaining participants, which might lead to trials delays or cancellations, which is not only a waste resources but, more importantly, it might lead to inconclusive results. Again, based on similar cases, we proposed to opt for a single arm trial instead of a randomized trial, meaning that all participants will receive AP. This will provide the same protection of participants and scientific rigor of a randomized trial, but it will simplify reaching an adequate sample.(A. Cavolo & D. Pizzolato, 2024; Alice Cavolo & Daniel Pizzolato, 2024) Similarly, when it comes to AP implementation, as previously mentioned, for the parents deciding whether to accept AP means deciding whether they want active treatment or palliative care for their infant, a decision-making for which we have already a substantial amount of information on what are the challenges and possible solutions. For example, one major challenge will be to convey complex information under time pressure, which is already a major challenge in treatment decisions at birth for EPIs. We know that ward tours or take-home materials (e.g., leaflets, videos) are helpful for parents, and, therefore, we can imagine they will be helpful also in AP decisions.(A. Cavolo & D. Pizzolato, 2024; Alice Cavolo & Daniel Pizzolato, 2024) Hence, by looking at comparable scenarios, we can identify possible future challenges as well as possible ways to address them. Obviously, we will never be able to foresee everything, and some solutions might result suboptimal or even pointless, but we can at least tackle some of the foreseeable issues.

4. How to move forward: What we learnt from the AP debate

This article is primarily aimed at understanding 1) why AP is not disruptive, and as such it will not be an existential threat, and 2) what are the risks of considering AP an existential threat. Hence, discussing how to better discuss innovative technologies in general is beyond the scope of this article. However, I think it is useful to at least indicate some ways to move forward in the discussion about AP and any other innovative technology in a more constructive way, based on what we learnt from the AP case.

First, do not confuse ethical challenges with existential threats. It is important that scholars are aware that just because an innovative technology is challenging, it does not mean that it will be disruptive or an existential threat. Some technologies will be truly disruptive and should be regarded as existential threat. For example, the introduction of incubators and surfactants was truly disruptive as it completely revolutionized neonatal intensive care and created an entire new population of patients (EPIs) who did not exist before. Should we achieve an artificial womb, that would be both disruptive and an existential threat. Disruptive because it will completely revolutionize reproductive care and potentially social norms, relationships and dynamics. An existential threat because it might seriously put in question what makes a human being. Further, it will decouple reproduction and womanhood, which were always thought as indissoluble, and it might deeply affect how we conceive humans, families, and society. However, many technologies are not. One might say that it is good to be prepared for the worst-case scenario even if it will not eventually occur. However, we previously saw that overblowing the potential of a technology can be harmful, for example by undermining the trust of the public in the technology or by proposing inadequate solutions. The opposite is also true and should be remembered. Just because a technology is not an existential threat, it does not mean that it will not be challenging. The challenges should be carefully investigated and as much as possible addressed beforehand or in the first implementation period.

Consequently – second point – scholars should be realistic about the potential of the technology. Speculation has an important place in ethical debates so it should not be avoided altogether but it is important that scholars explicitly state that 1) they are speculating about hypothetical different uses of an existing technology, or 2) that they are talking about a possible, but not yet invented, future technology. To make a practical example, should artificial wombs become reality, they might truly be an existential threat as they might disrupt our experience and conceptualization of pregnancy and parenthood. Hence, I see the value of discussing what could be the implications of such a technology and whether such a technology would be desirable in the first place. However, artificial wombs might also not be as disruptive as we think as it will depend on what the technology will be (at the moment we can only speculate), how it will be used, etc. etc. Hence, it is fundamental that scholars specify that they are speculating about a technology unrelated to current APs and that, should artificial womb become a reality, they are ready to adapt their analysis and advice to the new technology rather than remaining anchored to previous suggestions made for a hypothetical technology. For example, Stratman initially promoted the idea that AP could be used as an alternative to abortion,(C. M. Stratman, 2021) but in a later publication he specified that this is not a viable option for current APs due to clinical and ethical concerns.(Christopher M. Stratman, 2021) This type of intellectual honesty should be acknowledged and endorsed. In discussing a new technology, scholars should also remember that words matter. I understand the need to use precise terminology among experts, be it a legal, medical, or scientific terminology, but we need to be flexible and adapt our terminology to the context. For example, in a care context, referring to a fetus as “child” could be more sensitive, although less scientifically correct, than using the term fetus, as long as the parents specifically indicated that this is what they want. Similarly, in informing the public we should avoid misleading terms, even if technically more accurate.

Third, scholars should avoid focusing exclusively on long-terms effects. One of the biggest problems of the current AP debate is that the debate is thwarted toward long-term issues of AP, whereas equal importance should be given to more urgent short-term issues. Otherwise, the risks of those who will undergo the first in-human trial and implementation phase of any given technology/treatment will be overlooked and unaddressed. Similarly, it is important to also not only focus on the positive or negative implications of a technology as this will generate a biased debate that gives the impression that the technology at hand is either the magic solution to all evils or that it serves no purpose. The debate should always be balanced and account for both the goods and bads. To do so, it is also important that risks and benefits are evaluated within context. For example, AP has been considered particularly harmful for pregnant people because many prototypes require a C-section, which is riskier than a vaginal birth. However, this does not take into account first the fact that EPIs are more likely to be born via C-section than infants born at terms, making AP not so much more harmful than other preterm deliveries, and second that some groups are attempting to develop an AP compatible with vaginal delivery.(Zimmer, 2021)

As a segue from the previous point – point number four – the debate should be nuanced. As we saw in the case of AP, often technologies will not be univocally beneficial or harmful, not only because they will all entails harms and benefits, but also because they can be disruptive if used in a certain way and beneficial if used in others. It is important to offer a comprehensive and nuanced analysis and to adapt the solutions to every specific use of the technology rather than offering a one size-

fits-all kind of solution. I do appreciate that some scholars will have an expertise or interest in one particular field and, therefore, they will focus on the implications of an innovative technology in that field. That is normal and to a certain extent desirable as it is difficult for someone to understand all the implications of a technology in every single area. If we look back at the AP debate for example, world renowned experts on reproductive rights such as Romanis or Horn, provided a very acute and on-point analysis of the risk of AP for reproductive rights, but their discussion of the AP implications in the neonatal intensive care setting was not as on-point and at times problematic. It is easy to understand that they might have overestimated the risks of AP in neonatal intensive care or AP differences with current treatments, as this is not their expertise. To the opposite, neonatal and maternal-fetal specialists correctly identified the risks in intensive care but completely overlooked AP disruptive potential for reproductive rights. I understand that they never meant for AP to be used in the abortion context, but this unfortunately does not mean that it will never be used that way. However, it is important that these scholars clearly specify that they are focusing on one aspect/use of the technology and that they are aware that just because the technology is disruptive in one context does not mean that it is a disruptive technology per se. This will allow for a much more nuanced, comprehensive, and constructive debate that will hopefully result in more apt and actionable solutions. Working in interdisciplinary groups including various experiences and expertise (e.g., healthcare providers, developers, lawyers, parents, activists) would also add value to a more holistic and nuanced debate.

5. Conclusions

Should artificial placentas (AP) trials be successful, APs are expected to significantly improve mortality and especially morbidity rates for extremely preterm infants (EPI). This would correspond to a substantial improvement of clinical outcomes for a population that still suffers from high mortality and morbidity rates. Unfortunately, AP success is being jeopardized on two fronts. First, equating AP to an existential threat could lead to hindering research due to public fears of unrealistic risks of AP. Even if this does not happen, and for now it is not happening, regarding AP as a threat might still lead parents to refuse it, hindering, in this way, care for vulnerable infants who might have greatly benefitted from it. Second, focusing only on the exciting promises of AP and/or on futuristic scenario is leading us to overlook concrete challenges posed by the technology especially in the trial phase. The prospect of improving quality of life of EPIs or of a future artificial wombs are understandably much more exciting topics than counselling or recruitment strategies. However, overlooking more practical issues like counselling might add unnecessary stress to an already stressful situation. Similarly, without an effective participants' recruitment and retainment strategy AP trials risk delays and evn cancellations. Meaning that we will not have conclusive results on the effectiveness of the trial and very vulnerable participants (both infants and pregnant persons) were pointlessly subjected to the trial risks.

To avoid repeating these mistakes, both for APs and for other innovative technologies, I drawn some general suggestions on how to better approach innovative technologies based on what we learnt from the AP case: 1) do not confuse ethical challenges with existential threats; 2) be realistic about the technology's potential; 3) give equal attention to short- and long-term issues; and 4) provide a nuanced analysis. Following these steps should help building a constructive debate, inclusive of all the relevant stakeholders, that allows to identify risks and benefits of the technology in all its possible uses and to address challenges appropriately.

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