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A NEWDAWN? ECTOGENESIS, FUTURE CHILDREN AND REPRODUCTIVE CHOICE

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Introduction

Medical technologies such as IVF, surrogacy, mitochondrial donation, PGD, gamete and embryo donation, and uterus transplants offer many different solutions to those who suffer with infertility, as well as providing options for having healthy children. There is a new reproductive choice on the distant horizon that is ectogenesis, '... *commonly defined as the* "extrauterine gestation of human fetuses from conception to 'birth' , although it could also entail artificial incubation of an embryo or fetus transferred from a woman's uterus after conception"¹ Put simply, ectogenesis involves developing a foetus wholly or partially outside of a human body, for example, in an artificial uterus. Many feminists have argued that ectogenetic research should be pursued in order to revolutionise reproductive choice and services in order to liberate women from their reproductive role and from the expectations of a patriarchal and pronatalist society.² In contrast, the aim of this article is to contemplate and consider the implications of ectogenetic reproduction for future 'ecto-children', so as to generate debate about some of the hitherto neglected repercussions of this reproductive technology. For the purposes of this article, ectogenesis is approached as a technically possible method of reproduction.

Ectogenesis as a reproductive choice for women has been debated widely over recent decades; however, the impact upon future 'ecto-children' has been largely ignored by academics.³ The main focus of the article is to consider if the welfare and best interests of future ecto-children is served by either partial or complete ectogenesis. The article is divided into three sections. The first considers the likelihood of ectogenesis in the near future, the second briefly reflects upon the arguments put forward for ectogenesis as a reproductive choice for women in order to give context to the debate, and the third examines when partial and complete ectogenesis may benefit the welfare and best interests of future children. The pre-conception welfare principle in the Human Fertilisation and Embryology Act 1990 (as amended) is interpreted and applied to future ecto-children. The discussion is a thought experiment which assumes that ectogenesis has been established as a medically safe and effective method of reproduction, rather than an experimental procedure. With reproductive technology moving at a fast pace it is vital that ectogenesis is debated now to decide how we can regulate this practice in a way that considers the perspectives of all who are involved.⁴ Whilst ectogenesis as a reproductive treatment is still hypothetical, in a bid to seek proactive rather than reactive regulation, it is prudent to consider the welfare of future children that may be gestated *ex utero*. It is entirely possible that a whole new set of principles and legislation would be needed in order to encompass ectogenesis children's welfare; for the purposes of this article current principles and legislation have been interpreted and applied to this novel reproductive technology in an attempt to show that current legislative provisions do not easily accommodate this new technology, and hence the need for new provisions to govern such a novel reproductive advance.

1. E Kendal, *Equal opportunity and the case for state sponsored ectogenesis* (Palgrave, 2015) at page 2 citing MA. Warren, Review of *Making babies: the new science and ethics of conception* by P Singer and D Wells;(1986) 97(1) *Ethics* 288 to 289.
2. For example see, Kendal (Note 1 above); A Smajdor, 'The moral imperative. for ectogenesis' (2007) 16 *Cambridge Quarterly of Healthcare Ethics* 336 to 345; G Corea, *The mother machine: reproductive technologies from artificial insemination to artificial wombs* (The Women's Press, 1985).
3. Welfare of the future child is recognised by A Algranl, 'The legal and ethical ramifications of ectogenesis' (2007) 2 *Asian Journal of WTO & International Health Law & Policy* 189. The best interests of the children are briefly discussed by G Pence, 'What's so good about natural motherhood? (In praise of unnatural gestation)' in S Gelfand .and JR Shook (eds.) *Ectogenesis: artificial womb technology and the future of human reproduction* (Rodopi, 2006).

ectogenesis as a reproductive choice for women in order to give context to the debate, and the third examines when partial and complete ectogenesis may benefit the welfare and best interests of future children. The pre-conception welfare principle in the Human Fertilisation and Embryology Act 1990 (as amended) is interpreted and applied to future ecto-children. The discussion is a thought experiment which assumes that ectogenesis has been established as a medically safe and effective method of reproduction, rather than an experimental procedure. With reproductive technology moving at a fast pace it is vital that ectogenesis is debated now to decide how we can regulate this practice in a way that considers the perspectives of all who are involved.⁴ Whilst ectogenesis as a reproductive treatment is still hypothetical, in a bid to seek proactive rather than reactive regulation, it is prudent to consider the welfare of future children that may be gestated *ex utero*. It is entirely possible that a whole new set of principles and legislation would be needed in order to encompass ectogenesis children's welfare; for the purposes of this article current principles and legislation have been interpreted and applied to this novel reproductive technology in an attempt to show that current legislative provisions do not easily accommodate this new technology, and hence the need for new provisions to govern such a novel reproductive advance.

Is ectogenesis a near possibility?

As Gelfand notes, 'The idea of ectogenesis is hardly novel'.⁵ Since Haldane first coined the term 'ectogenesis', ectogenesis and artificial uteruses have appeared in fiction and movies throughout the twentieth century.⁶ Ectogenesis has also generated academic discourse over the last few decades.⁷

Although ectogenesis and artificial uteruses may sound like the product of active imaginations of science fiction writers, in light of the research and progress achieved in mimicking functions of the female uterus in neo/natal intensive care units, I believe that complete ectogenesis will become a feasible research area in its own right in the near future, and therefore reproductive choice. The human clinical trials for uterus transplants have been welcomed in the press, but despite two decades of animal research studies, it is only now that we are having public debate about the ethics, impact and problems with and benefits of uterus transplants; those debates should have been publicly discussed before human clinical trials were approved.⁸ Whilst uterus transplants have received research ethics committee approval, debate is needed in a bid for proactive regulation of new reproductive technologies. As Alghrani notes, 'Waiting until these technologies are possible to debate these questions is imprudent, for new technologies are marked by the rapidity at which they develop'.⁹ If complete ectogenesis

4. Whilst I do not claim that ectogenesis as a reproductive choice is imminent, there is progress in this area. In 2017 researchers were able to maintain extremely premature lambs in an artificial uterus for about four weeks: E Partidge et al., 'An extra-uterine system to physiologically support the extreme premature lamb' 25 April 2017 *Nature Communications* 1 to 14.
5. S Gelfand, *Introduction* in Gelfand and Shook (Note 3 above) at 3.
6. For example, Haldane, *Daedalus or Science and the future* (1925); A Huxley, *Brave New World* (1932); S Firestone, "The *dialectic of sex* (1970); M Piercy, *Woman on the edge of time* (1976); *The Matrix* (1999); *Star Wars episode 2: Attack of the clones* (2002); *The Island* (2005).
7. For example, P Singer and D Wells, *The reproduction revolution: new ways of making babies* (Oxford University Press, 1984); C Overall, 'Rethinking abortion, ectogenesis, and fetal death (2015) 46(1) *Journal of Social Philosophy* 126 to 140; S Wellin, 'Reproductive ectogenesis: the third era of human reproduction and some moral consequences' (2004) 10(4) *Science and Engineering Ethics* at 615.
8. A Sifferlin, 'First U.S. Baby Born After a Uterus Transplant' *Time*, 1 December 2017; N Hammond-Browning, 'Criteria for uterus transplants: looking ahead', manuscript in progress; N Hammond-Browning, 'Womb transplants-is surrogacy safer?' *Bionews* 828, 16 November 2015.
9. A Alghrani, 'Uterus transplantation: does procreative liberty encompass a right to gestate?' (2016) *Journal of Law and the Biosciences* 1-6 at 6.

becomes possible, it will impact fertility services and reproductive choice for future parents. Potentially, it could overcome the need to find women who will act as surrogates, women could become mothers without the need to gestate children, single men and male homo-sexual couples would no longer be socially infertile, and the transgender and non-binary community would have greater reproductive choice. Also, as ectogenetic foetuses would not be contained within the female body, foetal abnormalities could be operated upon without risk of physical harm to a woman.¹⁰ There are also arguments that partial ectogenesis could end the need for termination of foetal life when a woman ends her pregnancy, although discussion around separation theory and rights to abortion are beyond the scope of this article.¹¹

The creation of an artificial uterus for complete ectogenesis may come to fruition sooner than we think. As Coleman recognises, '... it would seem that there are two ways in which ectogenesis might be achieved: the direct research method, and the indirect research method'.¹² Direct research includes work developing an artificial uterus and an artificial placenta (more commonly known as extracorporeal circulation). The indirect research method to which Coleman refers concerns the developments aimed at increasing the survival rates of premature babies. As Simonstein notes, 'Neonatal care has expanded from caring for neonates who need only a few hours, or days, of special care after delivery, into an ever-expanding frontier of prolonged, aggressive treatment for smaller and smaller infants. Yet these infants are dependent on external life support ... "technological wombs" ...'.¹³ Developments aimed at saving the lives of very premature infants are slowly decreasing the amount of time that a foetus must spend within a woman's uterus in order to survive. The ability to care for premature babies and the corresponding increase in survival rates show that these 'technological wombs' have made a significant impact. However, the impact is not all positive, as the increase in survival-to-discharge rates have not seen a 'difference in the level of ongoing illnesses or complications affecting these surviving babies, including respiratory problems, brain damage and eye disease of prematurity',¹⁴

Direct research aimed at creating an artificial uterus includes the development of a system of extrauterine incubation in the late 1980s by a team in Tokyo. They were able to transfer nine goat foetuses into an incubator containing artificial amniotic fluid; these were incubated for several days.¹⁵ Progress continues to be made in this area with the announcement in April 2017 of 'the lamb in a bag'. Developed by a team in Philadelphia, researchers have developed an extra-uterine system to successfully support extremely premature lambs.¹⁶ In 2003, Dr Liu and her team at Weill Cornell Medical College, Cornell University reported that they had procured and seeded mouse endometrial cells onto a collagen scaffold to construct a 3D-engineered structure that was then used to implant mouse blastocysts. These blastocysts were able to develop, and their data also showed that they were able to successfully transfer an embryo to a surrogate mother mouse after two days' development in the artificial uterus structure resulting in a fully developed foetus after 17 days' gestation.¹⁷

10. Women have to undergo incisions into the abdomen in order to access the uterus; this has risks of miscarriage and pre-term labour as well as risks with anaesthesia. Foetal abnormalities that may be treated by foetal surgery include spina bifida, congenital diaphragmatic hernia, and twin/twin transfusion syndrome: *Surgery Encyclopedia* <http://www.surgeryencyclopedia.com/Ce-Fi/Fetal-Surgery.html>.

11. For example, L Cannold, 'Women's response to ectogenesis and the relevance of severance abortion theory', Masters dissertation, Monash University, 1992; E Mathison and J Davis, 'Is there a right to the death of the foetus?' (2017) 31(4) *Bioethics* 313-320; J Räsänen, 'Ectogenesis, abortion and a right to the death of the fetus' (2017) 31 *Bioethics* 697-702.

12. S Coleman *The ethics of artificial uteruses: implications for reproduction and abortion* (Aldershot: Ashgate, 2004) at page 5.

13. F Simonstein, 'Artificial reproductive technologies and the advent of the artificial womb' in F Simonstein (ed.) *Reprogen-ethics and the future of gender* Dordrecht Heidelberg London New York: Springer, 2009) at page 178.

14. *Premature birth survival rates on the rise*, NHS <http://www.nhs.uk/news/2012/12December/Pages/Premature-birth-survival-rates-on-the-rise.aspx>; (accessed 24 February 2017). An increase in survival rates from 40 per cent in 1995, to 53 per cent in 2006 was reported.

15. Y Kuwabara, *et al.*, 'Artificial placenta: long-term extrauterine incubation of isolated goat foetuses (1989) 13(6) *Artificial Organs* 527-531.

16. Partidge *et al.*, Note 4 above.

In 2009, Chinese scientists in Beijing reconstructed engineered uterine tissues with a smooth muscle layer, akin to the normal uterine wall. They reported that 'The reconstructed EUT's [engineered -uterine tissue] could support the development of embryos'.¹⁸ In 2013, another Chinese team at Guangzhou developed an artificial uterus on a microfluidic chip '... to mimic the microenvironment of uterus. Such a microfluidic uterus facilitated embryo development through the perfusion of co-culture of oocytes with endometrium cells'.¹⁹ This microfluidic chip was designed to improve the culture of embryos in vitro prior to implantation. This research demonstrates that complete ectogenesis is a distinct possibility.

The most significant recent scientific development is the announcement by Professor Mats Brännström that his team are developing bioengineered artificial uteruses. Brännström leads the team that has successfully performed the first human uterus transplants that resulted in live births.²⁰ The reason for the development of bioengineered uteruses is to overcome problems with an appropriate supply of donated uteruses, as well as issues with the use of immunosuppressant drugs after transplantation.²¹ If a bioengineered uterus can be grown in the laboratory using the potential recipient's own cells, it can be transplanted into the recipient's body for gestational use.

Whilst the goal to overcome absolute uterine factor infertility in a way that is as safe as possible for the recipient and the future child may be noble, the bioengineered uterus could be a stepping stone towards complete ectogenesis. Where once we did not envisage being able to grow embryos in vitro up to and beyond 14 days, debate on the merits of removing the legal restrictions in order to allow longer-term development of embryos in vitro is now ongoing.²² In much the same way, scientists may intend to develop a bioengineered uterus for transplantation to the female body, but further scientific developments and discoveries may soon make it feasible to maintain the uterus outside of the female body. This development would have enormous significance for medicine, law, society, politics and ethics. No longer would every person on the planet have a birth mother, foetal rights could potentially override parental wishes, and a new kind of person would exist -the ecto-human. Legally, this will only be permissible in the United Kingdom if the current 14-day time limit on keeping embryos in vitro is either completely removed, or amended to allow for ex utero gestation, otherwise it is a criminal offence that is punishable by up to ten years' imprisonment, a fine, or both.²³

How soon an artificial uterus may exist that is suitable for use from conception to birth by the human population is not possible to predict accurately. Brännström believes that a bioengineered uterus may be suitable for transplantation into the human body within the next ten to 15 years.²⁴ Similarly, Coleman notes in his analysis of the state of scientific play, there are hurdles that science must overcome, but '... none of the problems appear to be insurmountable'.²⁵ With the development of bioengineered uteruses the scientific hurdles are gradually being jumped.

17. HC Liu, ZY He, CL Chen and Z Rosenwaks, 'Ability of three-dimensional (3D) engineered endometrial tissue to support mouse gastrulation *in vitro*' *Fertil Steril* 2003;80:S78.
18. Lü *et al.*, 'Reconstruction of engineered uterine tissues containing smooth muscle layer in collagen/matrigel scaffold *In vitro*' *Tissue Engineering Part A*. July 2009, 15(7): 1611-1618, Abstract.
19. Li Wei-Xuan *et al.*, *Artificial uterus on a microfluidic chip* [2013] 41(4) *Chinese Journal of Analytical Chemistry*, 467-472, Conclusion.
20. M Brännström *et al.*, 'Livebirth after uterus transplantation' (2015) 385 *Lancet* 607-616.
21. M Hellström *et al.*, 'Bioengineered uterine tissue supports pregnancy in a rat model' [2016] *Fertility and Sterility* 106(2) 487-496 at 487.
22. For example, *Rethinking the Ethics of Embryo Research: Genome Editing, 14 Days and Beyond*, Progress Educational Trust annual conference, 7 December 2016, Institute for Child Health, London; J Harris 'It's time to extend the 14-day limit for embryo research', *The Guardian*, 7 May 2016: <https://www.theguardian.com/commentisfree/2016/may/06/extend-14-day-liml-embryoresearch> (accessed 9 May 2017).
23. Section 41 Human Fertilisation and Embryology Act 1990 (as amended).
24. S Knapton, 'Infertile women could get new wombs grown from stem cells within 10 years, says transplant pioneer', *The Telegraph*, 20 June 2016.
25. Coleman, Note 12 above, at 13.

Ectogenesis as a reproductive choice

Ectogenesis has generated a significant amount of discussion that focuses on who and why people should have access to it.²⁶ The question of who should have access to assisted reproductive technologies has altered significantly since the first IVF birth in 1978. Whereas the traditional heterosexual married couple was the epitome of family life in the 1970s, today it is recognised that parents of any background, sexual preference or marital status are able to raise children as well as heterosexual married couples.²⁷ This is recognised in the UK context, as access to assisted reproductive technologies is not legally restricted to heterosexual married couples.²⁸ The social acceptance of non-traditional families is of benefit to children, as the recognition that anyone can and should be able to adopt has broadened the range of possible adoptive parents.²⁹

Due to the physical, social, ethical and financial impact that complete ectogenesis will have for women, they have been the focus of the literature to date.³⁰ The cultural and societal view of women, as well as women's own self-perceptions would likely be dramatically altered since women's bodies could be dispensed with as a method of reproduction.

In 1985, Singer and Wells argued that, 'Medically speaking, ectogenesis offers an alternative to surrogate motherhood for women who are incapable of pregnancy or for whom pregnancy is not recommended on medical grounds ... [and] claim that ectogenesis should be chosen in preference to surrogacy'.³¹ The use of an artificial uterus as an alternative to surrogacy might at first sight be applauded due to concerns around the exploitation of women or, as Singer and Wells noted, due to worries about possible custody battles, surrogates taking harmful substances during the pregnancy, a shortage of women, or high costs of employing women to act as surrogates.³² Some authors argue that complete ectogenesis should be developed on the grounds of social justice, equal opportunities and increasing reproductive choice.³³ Although the use of artificial uteruses may not be legally mandated for reproduction, if they are promoted as the 'correct' reproductive choice to make, complete ectogenesis could undermine the right of women to choose how they use their reproductive capacity. The use of artificial uteruses may be encouraged to prevent exploitation of women, to avoid risks to female health, to prevent disruption in the labour market, or for the benefit of the future child. At the extreme is the claim that ectogenesis could see the elimination of women.³⁴ As Sander-Staudt argues, 'feminists have reason to ... stand against the development and use of full ectogenesis on the principle that it is inherently demeaning and disempowering to women as biological mothers'.³⁵ Female gestation may become socially stigmatised and women pressured into making decisions about how to use their reproductive capacity. Therefore, I argue that if complete ectogenesis becomes a safe method of reproduction, it should be a choice to use it; otherwise we risk undermining the battles that have been fought for women's reproductive rights and respect for autonomy.

26 For example, Gelfand and Shook, Note 3 above; Corea, Note 2 above; P Singer and D Wells, *Making babies: the new science and ethics of conception* (New York: Charles Scribner's Sons, 1985); I Arlstarhova, 'Ectogenesis and mother as machine', (2005) *Body&: Society* 11(3), 43-59.

27 Note the recommendation of the Warnock Committee that fertility treatment should be provided to a heterosexual couple: *Committee of Inquiry into Human Fertilisation and Embryology (Warnock Report)* (1984) Department of Health, Cmnd 9314, at 2.11.

28 Section 13 Human Fertilisation and Embryology Act 1990 (as amended).

29 Note the recent debate around the right to know your biological parents and the benefit to children, V Ravitsky, J Guichon, M Lemoine and M Giroux 'The conceptual foundation of the right to know one's genetic origins' *Bionews* 903 (5 June 2017).

30 For example Corea, Note 2 above.

31 Singer and Wells, Note 26 above, 116-134 reproduced in Gelfand and Shook, Note 3 above, chapter 2, 11.

32 Singer and Wells, Note 31 above.

33 Smajdor, Note 2 above; Kendal, Note 1 above; Pence, Note 3 above.

34 As discussed by J.S. Murphy, 'Is pregnancy necessary; feminist concerns about ectogenesis in Gelfand and Shook, Note 3 above, at 36.

35 M Sander-Staudt, 'Of machine born? A feminist assessment of ectogenesis and artificial wombs', in Gelfand and Shook, Note 3 above, at 127.

Smajdor supports complete ectogenesis on the basis that 'pregnancy is barbaric'.³⁶ Kendal argues that no one would choose pregnancy and childbirth if they were fully informed of the risks and harm to the physical body. In contrast to Smajdor, who advocates for ectogenesis on the basis of a health need, Kendal advocates for ectogenesis as a reproductive choice, viewing ectogenesis as 'a much-needed *option* for those women who wish to have children without submitting to the physical burdens of gestation and childbirth'³⁷ ,Pregnancy is physically demanding for women; for many the physical toll does not end upon birth. Pelvic floor injuries, joint problems, infections and mental health issues are just a few. I agree with Kendal, if complete ectogenesis is proven as a safe method of reproduction for the future child, then it should be a reproductive choice to use.

Today there is a wealth of information available detailing the risks of pregnancy and childbirth, and the problems that are faced by many such as pelvic floor problems and postnatal depression.³⁸ Yet women still choose to become pregnant, and often more than once. If complete ectogenesis and artificial uteri are shown to be a safe way to produce a healthy child, then this may be a reproductive choice that some women will want to pursue. Studies need first to be conducted amongst those who cannot otherwise reproduce to determine if there is a desire to utilise complete ectogenesis.³⁹ Uterus transplants are a useful comparator, as it appears that the desire to gestate is so strong that some women are willing to undergo multiple major surgeries in order to have a chance to gestate, even when other options for motherhood exist.⁴⁰

As a whole, there is a failure in the ectogenesis literature to discuss the benefits to women of carrying a pregnancy, and the benefits to children to be carried to term within the female body. Pregnancy and breastfeeding may reduce a women's risk of breast cancer, as well as lower the risks of ovarian and endometrial cancer.⁴¹ For children that are carried to term, the long-term health benefits are substantial, with lower chances of hospital admissions and improved cognitive and motor development.⁴² Smajdor does not engage with the benefits of gestation for women, even though she has taken a woman-centred health-needs approach in her support of complete ectogenesis .. Likewise, Pence notes only the possible short-term health benefits of ectogenesis for women.⁴³ Murphy also argues for 'a woman-centred reproductive agenda that makes visible the needs of all women' although compared to Smajdor this agenda is used to 'suggest that feminists must protest sexist research methods such as IVG [ectogenesis]'.⁴⁴

36 Smajdor, Note 2 above, at 341.

37 Smajdor, Note 2 above, at 340; Kendal, Note 1 above, Introduction, at 8.

38 For example, 24 per cent of American women suffer with pelvic floor disorders: HU Memon and VL Handa, 'Vaginal childbirth and pelvic floor disorders', [2013] *Women's Health*, 9(3); ten to 15 in every 100 women suffer from post-natal depression and anxiety, Royal College of Psychiatrists, 'Postnatal depression': <https://www.rcpsych.ac.uk/healthadvice/problemsanddisorders/postnataldepression.aspx> (accessed 8 June 2018).

39 Those who are otherwise unable to reproduce are the obvious first users of ectogenesis. Those who would utilise the technology due to a lifestyle may also wish to access this reproductive technology, and further studies will be needed to assess the demand.

40 D.Orentlicher, *Toward Acceptance of Uterus Transplant*. Hastings Center Report 42, No 6 (2012) at 12 to 13; R Catsanos, W Rogers and M Lotz, 'The Ethics of Uterus Transplantation' [2013] *Bioethics*, 27(2) at 65-3; N Hammond-Browning (16 November 2015) 'Womb transplants – is surrogacy safer?' *Bionews* 828: http://www.bionews.org.uk/page_586364.asp (accessed 9 January 2017)

41 I do acknowledge that the reports are varied in their predicted outcomes post partum. For example, Kobayashi et al. note that the risk of breast cancer following birth varies depending on the age of the mother and the duration of breastfeeding: Kobayashi et al., 'Reproductive history and breast cancer risk' (2012) *Breast Cancer* 19(4) 302-308.

42 EV Espe!, IM Glynn, CA Sandman and BP Davis, 'Longer gestation among children born full term influences cognitive and motor development' (2014) *PLoS ONE* 9(11); LI Parikh *et al.*, 'Neonatal outcomes in early term birth' (2014) *American Journal of Obstetrics and Gynecology* 211(3) 265.

43 Pence, Note 3 above, at 83.

Engagement with children's welfare and best interests is also limited; Smajdor does not engage in a discussion of the effects of an ectogenetic pregnancy on the future child beyond showing that it is not necessary to gestate in order to have a bond with a child.⁴⁵ In contrast, Pence engages with the best interests of future children in so far as he notes two circumstances that may favour the development of ectogenesis: a drug-free environment, and surgery to correct defects such as hydrocephaly.⁴⁶ Whilst the United Kingdom does not recognise a legal being in *utero*, future children do have moral significance and legal impact; the foetus is protected under the Offences Against the Person Act 1861. Legal exceptions to the absolutist approach in the 1861 Act exist, demonstrating overall a gradualist approach towards the developing embryo.⁴⁷ Future children should not be ignored in the ectogenesis debate. In the next section, I examine partial and complete ectogenesis in order to determine if either process benefits the welfare and best interests of future children.

Ectogenesis and future ecto-children

The scientific progress in this area of reproductive science is hard to predict accurately. When artificial uteri become available for human use, the current lack of engagement with the ethical and legal issues will become apparent. Whilst science and medicine can explain how an embryo is created and its developmental stages, the research into reasons for failed implantations, miscarriages, genetic defects and unexplained infertility is still in the developmental stages itself. The last frontier of reproductive science is the use of an artificial uterus, enabling researchers to have easy access to the developing embryo / foetus to study it, and enabling people to reproduce.

Although there is significant literature on the impact of complete ecto-genesis upon women, there is a lack of serious discussion around the future ecto-children and potential benefits and harm to them by pursuing ecto-genetic research.⁴⁸ The best interests and welfare of future children born from an artificial uterus demand consideration. For the purpose of this article, the current legislation is interpreted and applied to ectogenesis to demonstrate the need for proactive legislation. The pre-conception welfare principle in section 13(5) Human Fertilisation and Embryology Act 1990 (as amended) is applied.

Section 13(5) Human Fertilisation and Embryology Act 1990 (as amended) states that, 'A woman shall not be provided with treatment services unless account has been taken of the welfare of any 'child who may be born as a result of the treatment (including the need of that child for supportive parenting), and of any other child who may be affected by the birth'. The Code of Practice of the Human Fertilisation and Embryology Authority ('the HFEA') provides further guidance, requiring fertility centres to 'assess each patient and their partner (if they have one) before providing any treatment, and should use this assessment to decide whether there is a risk of significant harm or neglect to any child'.⁴⁹ The factors assessed relate to the history and the behaviour of the intended parent(s) and its significance for the future child, it is not an assessment upon how the reproductive technology may

44 JS Murphy, 'Is pregnancy necessary: feminist concerns about ectogenesis' in Gelfand and Shook, Note 3 above, at 42 to 43.

45 Smajdor, Note 2 above, at 343.

46 Pence, Note 3 above, at 82.

47 N Hammond-Browning, 'Ethics, embryos and evidence: a look back at Warnock' (2015) *Medical Law Review* 23(4) at 588 to 619. A gradualist approach is evident upon examination of the Abortion Act 1967 and the Human Fertilisation and Embryology Act 1990 (as amended), as termination and research is permitted up to certain embryological developmental time limits (noting that termination is permitted up to term in limited circumstances).

48 Welfare of the future child is recognised by Alghrani, Note 5 above. The best interests of the children are briefly discussed by Pence (Note 3 above).

49 8.3, Code of Practice, HFEA, Version 3.0: [https://www.hfea.gov.uk/code-of-practice/8#section- header](https://www.hfea.gov.uk/code-of-practice/8#section-header).

impact the future child.⁵⁰ This is under-standable as current methods of assisted reproduction have been proven safe, although initially there were worries around IVF, and it must be emphasised that studies have shown that being open with children as to their origins is important for children's wellbeing.⁵¹ This would equally apply to ecto-children. In order to apply the pre-conception welfare principle to future ecto-children, it is necessary to take a new approach and expand the application of the principle from pre-conception to include pre-birth. The welfare of the foetus in utero (whether female or artificial) and the risk of significant harm can then be assessed. Additionally, the factors for assessment listed in the Code of Practice will also require expansion. This new interpretation and application of the welfare principle to pre-conception and pre-birth scenarios for the purpose of ectogenesis must not negatively impact access to termination of pregnancy, as this involves considerations of women's health as well as foetal interests. It is preferable to limit its application to ecto-foetuses.

The pre-conception welfare principle is not without its critics; Waxman has argued that, 'a principle based on assessing a harm which has not yet been caused to an individual that does not yet exist - such as the PCWP [pre-conception welfare principle] - is rendered unworkable'.⁵² Jackson states that 'If s13(5) is genuinely directed towards safeguarding the interests of future children, it is a haphazard and inefficacious sort of child protection'.⁵³ I do not deny that section 13(5) is not without its faults; however, without proactive regulation in this area, the existing legislative provisions will be applied, and as such are worthy of exploration.

Partial ectogenesis

Partial ectogenesis occurs when pregnancy has started within the female uterus and the foetus is later transferred to an artificial uterus (note that the embryo may be created *in vitro*). Some commentators state that partial ectogenesis is already in use.⁵⁴ Incubators allow control of temperature and in some cases, humidity, which aids premature baby survival rates. In part, incubators act as replacements for the female uterus until the baby is able to survive outside of the incubator. Partial ectogenesis could be developed further with more complex artificial uteruses that involve the use of artificial amniotic fluid and support system. It is the development and use of this complex artificial uterus that is considered here,

Survival rates of premature births have improved in recent times due to the advances in medical technology that have overcome our natural limitations. The development of a more sophisticated artificial uterus may decrease the limits of viability further, but this must not be to the detriment of those who survive. Negative outcomes are common for very premature babies born before 23 weeks gestation; very premature babies born before 28 weeks with an extremely low birth weight have a 30

50 8.10, *Factors*, Code of Practice, HFEA, Version 3.0: <https://www.hfea.gov.uk/code-of-practice/8#section-header>.

51 For example, see the studies by S Golombok and colleagues: E Ilioi, L Blake, V Jadva, G Roman and S Golombok, 'The role of age of disclosure of biological origins in the psychological wellbeing of adolescents conceived by reproductive donation: a longitudinal study from age 1 to age 14' [2017] *Journal of Child Psychology and Psychiatry*, 58(3), 315-324.

52 S Waxman, *The pre-conception welfare principle: a case against regulation* (2017) PhD thesis, University of Manchester, at page 42,

53 E Jackson, 'Re-thinking the child welfare principle' in K Horsey and H Biggs (eds) *Human fertilisation and embryology: reproducing regulation* (Routledge-Cavendish, 2007) at page 66.

54 For example, F Simonstein notes how neonates 'move from the natural womb of their mothers to the "technological wombs" of Neo-Natal Intensive Care Unit': F Simonstein 'Artificial reproduction technologies (RTs) - all the way to the artificial womb?' (2006) *Medicine, Health Care and Philosophy* 9: 359-365 at 360.

to 50 per cent risk of mortality, and those that survive have up to 50 per cent risk of morbidity.⁵⁵ Whilst scientific and medical progress that improves survival rates and lowers morbidity rates for very premature babies is beneficial should we pursue research that may cause pain and suffering whilst it is developed? As Alghrani and Brazier note, 'we have no sense of the degree of risk that ectogenetic research will cause fetal pain and any such research must be designed to exclude such a possibility'.⁵⁶ In granting ethical approval for partial ectogenesis the potential for pain and suffering must be deliberated. It is uncertain how much pain foetuses feel *in utero*, so the transfer from a female uterus to an artificial uterus may cause significant pain, distress and suffering, as might the period of artificial gestation. Whether the potential for suffering is outweighed by the opportunity for survival requires reflection. For some, any chance of survival may be enough to outweigh the potential pain. We may never truly know if the foetus experiences any pain or suffering due to the foetal transfer, or the extent of that suffering. These considerations may prevent ethical approval of such research.

It is recommended that physical harm and suffering is added as one of the factors in the HFEA Code of Practice for assessing the risk of significant harm to the future child. This may be a difficult hurdle to jump in order to access partial ectogenetic services and complex artificial uteruses. However, whilst foetal transfer to a complex artificial uterus may involve significant risk of harm through potential suffering, this risk of harm might be lessened as the gestation period increases and as viability becomes significantly more likely. Therefore, there may be grounds for legally requiring a minimum female gestational period before permitting transfer to an artificial uterus. Sander-Staudt notes that pregnancy is 'a two-way interaction that is dynamic and responsive an exchange of growth and development'.⁵⁷ As development of the foetus progresses, the potential for viability increases, and it is this that may tip the scales in favour of foetal transfer despite the risk of suffering during transfer and subsequent artificial gestation.⁵⁸ This would support a legal minimum female gestation period before foetal transfer.

If the court becomes involved in a dispute between an NHS Trust and parents about the use of an artificial uterus for their very premature baby, the balance sheet drawn up will be significant. Due to the expedient nature of the majority of premature births, the court will become involved in emergency situations requiring fast decisions. Without appropriate guidance the balance sheet will be subjective. The court will have to balance the significant risk of suffering of the premature foetus during transfer, the risk of death and morbidities, and the potential for survival. As recognised by the court, there is a strong presumption to prolong life but that presumption can be, and has been, rebutted.⁵⁹

Notwithstanding the discussion above, the welfare and best interests of future children may be supported by the development of partial ectogenesis for particular circumstances. Specifically, for those future children who would otherwise be at risk of exposure to harmful substances that are ingested by the gestating woman, or are a high risk pregnancy due to medical reasons.⁶⁰ First, foetuses carried by women addicted to alcohol and/ or illegal drugs are at risk of foetal alcohol syndrome and neonatal abstinence syndrome. Severe consequences include learning disorders, hearing and sight problems,

55 HC Glass et al., 'Outcomes for extremely premature infants' (2015) *Anesthesia & Analgesia* 120(6): 1337-1351.

56 A Alghrani and M Brazier, 'What is it? Whose is it? Re-positioning the fetus in the context of research' (2011) 70 *Cambridge Law Journal* 51-82 at 80,

57 M Sander-Staudt, Note 35 above, at 119.

58 There is precedent for using viability to access services; the Abortion Act 1961 limits termination of pregnancy after 24 weeks gestation.

59 Great Ormond Street v Yate and others [2017] EWHC 972 (Fam). See also, N Hammond-Browning, 'When doctors and parents don't agree: the story of Charlie Gard' (2017) *Journal of Bioethical Inquiry* 14(4) 461, <https://doi.org/10.1007/s11673-017-9814-9>.

60 Supported by Pence, Note 3 above.

problems with the liver, kidneys or other organs, and epilepsy.⁶¹ Second, foetuses of pregnant women who require chemotherapy are at risk of termination. The medical advice is to terminate pregnancy as chemotherapy is harmful to the foetus, and delaying treatment is harmful to the gestating woman. Third, foetuses that are diagnosed with complex health needs of their own require. *in utero* surgery may benefit from transferral to, an artificial uterus.

In these circumstances partial ectogenesis could be offered as an option for treatment to gestating women. Women's bodily autonomy is legally recognised and consent must be given for the foetal transfer. It is not suggested that partial ectogenesis should be mandated as this would be a gross violation of autonomy; rather that a gestating woman in one of these situations may wish to utilise the option of partial ectogenesis.⁶²

Substance abuse

If a woman is a regular user of excessive alcohol and/or harmful drugs it may be justified to provide her with the option of an artificial uterus. Foetal transfer is justified as it is in the best interests of that particular foetus, as well as maximising the autonomy and choice of the pregnant woman. The risk of significant harm to the future child is reduced through the removal from substance abuse, and corresponding reduction in short- and long-term harm. If the welfare of the future child is taken into account, this strongly suggests that foetal transfer to an artificial uterus is in the foetus' best interests.

The best interests of the pregnant woman are potentially maximised, and there is also a resource benefit. If they wish, the women who choose to consent to foetal transfer would have time to seek treatment for their substance abuse problems, thereby creating a more secure environment for their future children after birth from the artificial uterus. It currently costs £1,500 per week to send a mother and her baby to the only centre in the United Kingdom that provides mother and baby drug and alcohol rehabilitation.⁶³ If an artificial uterus became more cost-effective than this, as well as showing health and social benefits to both the gestating woman and the future child, it may be justifiable to offer partial ectogenesis to pregnant women who are addicted to substance abuse. Recognition must be given to the fact that the availability of partial ectogenesis may encourage women to continue to abuse harmful substances, they may struggle to access services, or may be unable to break the addiction; partial ectogenesis will still be in the best interests of the future child as they will no longer be exposed to the harmful substances.

This is a situation where the welfare of the potential child(ren) is one that could justify the use of an artificial uterus with the woman's consent. In addition, the best interests of the gestating woman and any children that she may already have are also beneficiaries of the foetal transfer. It must still be the woman's choice to transfer the embryo/foetus from within her body into an artificial uterus, as her consent is required to perform such a procedure.⁶⁴

61 *Neonatal abstinence syndrome*, Stanford Children's Health <http://www.stanfordchildrens.org/en/topic/default?id=neonatal-abstinence-syndrome-90-P02387> (accessed 30 June 2016); *Foetal alcohol syndrome* NHS Choices <http://www.nhs.uk/Conditions/foetal-alcohol-syndrome/Pages/Introduction.aspx> (accessed 30 June 2016).

62 As noted, the foetus has no legal status and when a woman takes harmful substances during pregnancy, this will not result in a criminal offence. *CP (a child) v First Tier Tribunal (Criminal Injuries Compensation) and Others* [2014] EWCA Civ 1554.

63 F McCamley, 'Born addicts: the babies starting life in rehab'. BBC News, 25 November 2016: <http://www.bbc.co.uk/news/uk-37851654> (accessed 25 November 2016).

64 Article 8 ECHR: *Re MB (An Adult: Medical Treatment)* [1997] 2 FLR 426 per Butler-Sloss LJ; 'A competent woman who has the capacity to decide may, for religious reasons, other reasons, for rational or irrational reasons or for no reason at all, choose not to have medical intervention, even though the consequence may be the death or serious handicap of the child she bears, or her own death'.

Although welfare of the foetus is vital to help determine if foetal transfer to an artificial uterus should go ahead, in this scenario it cannot override the pregnant woman's interests. As the foetus is contained within her body she has the last say on whether her body can be touched and operated upon in order to remove the foetus to an artificial uterus.

Treatment for serious conditions

Foetuses carried by a woman who requires cancer treatment, or treatment for other similarly serious conditions, could also benefit from foetal transfer.⁶⁵ Pregnant women diagnosed with cancer either have to terminate their pregnancy in order to start treatment, or delay treatment until after birth but lower their own chance of survival. It is currently advised that pregnant women do not undergo standard cancer treatment during the first trimester due to the risk of harm to the foetus in utero.⁶⁶ Women in such situations (or similar) could be offered foetal transfer to an artificial uterus, thereby removing the risk of significant harm to the foetus through exposure to harmful drugs and radiation, and optimising their treatment. The foetal opportunity to continue development within the artificial uterus, free from risks of exposure to cancer drugs, also maximises foetal welfare.

Undoubtedly, partial ectogenesis also benefits women; they can start cancer treatment at the earliest opportunity, thereby increasing their own chances of survival, and are able to have their child. Kendal discusses the implications of ectogenesis for such women, arguing that: 'This is one area in which I argue that ectogenesis could make a particular contribution to women's welfare, as women would no longer have to choose between their health and that of their fetus when considering chemotherapy and radiation treatments - they could choose instead to transfer their fetus to an artificial womb before commencing treatment'.⁶⁷ Kendal views this situation from the perspective of benefiting women; I would argue that this is a situation where both the gestating woman and the foetus would benefit. If the high-risk pregnancy puts both the gestating woman and the foetus at risk, foetal transfer is in both parties' best interests. In contemplating foetal transfer the risk of significant harm to the foetus during transfer must be taken into account. As noted previously, this may require a minimum feminine gestational limit before foetal transfer.

65 This is one scenario that Kendal advocates for the use of artificial wombs Kendal (Note! above), Introduction, at 7.

66 'Cancer can be treated during pregnancy'; www.Cancer.org 31 May 2012; <http://www.cancer.org/cancer/news/news/cancer-can-be-treated-during-pregnancy> (accessed 13 January 2017).

67 Kendal (Note 1 above) Introduction, at 7.

Foetal health needs

Foetuses that are diagnosed with complex health needs that can be treated *in utero* may also benefit from foetal transfer to an artificial uterus. Some foetuses undergo intricate surgery that is performed through keyhole incisions in the woman's abdomen.⁶⁸ If such surgery could be performed more easily in an artificial uterus, thereby improving success rates and outcomes for the foetus, it may be in that foetus' medical best interests to be transferred. Foetal transfer can only proceed with the consent of the gestating woman as women's autonomy and right to consent to treatment is still the primary consideration.

There is one scenario where it may be in the foetal best interests to transfer to an artificial uterus but it is not possible to obtain the consent of the gestating woman. Partial ectogenesis is most beneficial where the gestating woman suffers brain death and is in a persistent vegetative state. At present, attempts are made to sustain the gestating woman in order to give the foetus the best possible chance to develop and to remain *in utero* for as long as possible. However, these attempts are often unsuccessful and there are ethical concerns.⁶⁹ Maintaining a woman in a PVS state in order for the foetus to develop to the point of viability is rare, and whilst some foetuses are maintained to the point of viability and delivered pre-term, the option of foetal transfer to a complex artificial uterus may allow for the foetus to develop until term whilst also preserving the dignity of the PVS woman, and allowing her to pass on and family and friends to grieve.⁷⁰

An elective foetal transfer to a complex artificial uterus could be justified where it reduces the risk of significant harm to the foetus and so can be shown to be in the foetal best interests: where it reduces the exposures to harmful substances, is an opportunity to continue to develop, or increases the chance of *in utero* treatment. The limited access to partial ectogenesis is recognition that the female body is typically the safest, most successful and economical method of reproduction. It is only in circumstances where the future child is at risk of significant harm through continuing gestation within the female body that offering partial ectogenesis may be justified, and undertaken with consent of the gestating woman. It is serendipitous that these circumstances also benefit the gestating woman.

68 KM Maseli and A Badillo, 'Advances in fetal surgery', [2016] *Annals of Translational Medicine* 4 (20) at 394; D Deka, V Dadhwal, SB Gajatheepau, A Singh, K Aparna Sharma and N Malhotra, 'The art of fetoscopy: a step toward minimally invasive fetal therapy' (2012) *The Journal of Obstetrics and Gynecology of India* 62(6) at 655 to 659; PAL Pedreira, EA Reece, RH Chmait, EV Kontopoulos and RA Quintero, 'Fetosopic repair of spina bifida: safer and better?' [2016] *Ultrasound in Obstetrics and Gynecology* 48 (2) at 141 to 147.

69 R Heywood, 'Live or let die?: fine margins between life and death .in brain-dead pregnancy' (2017) 25(4) *Medical Law Review* 628--653.

70 A Said, AJ Amer, MU Masood, A Dirar and C Faris, 'A brain-dead pregnant woman with prolonged somatic support and successful neonatal outcome: A gran rounds case with a detailed review of literature and ethical considerations' (2013) 3(3) *International Journal of Critical Illness and Injury Science* 220-224.

Complete ectogenesis

In contrast to partial ectogenesis, complete ectogenesis totally removes the need for a gestating woman. The embryo is created and developed *in vitro* before transferral to an artificial uterus where it develops and grows until its birth. There are a number of ethical social and legal concerns with this scenario that need consideration now, some of which were raised around the time of the first IVF births. IVF has given infertile people a reproductive choice and is seen as a success for reproductive medicine. That said, infertility treatment has not progressed completely without concern. It is estimated that over 6.5 million IVF babies have been born since Louise Brown's birth in 1978, and although no serious concerns have been raised about those IVF children in recent times, there are concerns around IVF multiple births (from both the children's and the mother's perspective) as well as some of the infertility add-ons.⁷¹

In order to consider if complete ectogenesis is in the best interests of future ecto-children or if it poses a risk of significant harm, the following section explores psychological harm and uterine experience as well as legal parenthood and termination of an ecto-pregnancy.

Psychological. Harm

The first ecto-children will be subject to long-term follow up studies, intense media interest, and social media discussion. As such, the first ecto-children may suffer significant psychological harm from the mere fact that they are the first children born from an artificial uterus. Media interest was intense for the parents of the world's first IVF baby, Louise Brown, who was born in an era free from the internet and social media.⁷² It has continued throughout her and her sister's lives (also an IVF baby with headlines announcing their own successful natural pregnancies. Louise Brown is repeatedly referred to in academic conferences, events and papers (such as this one).⁷³ More recently, ongoing intense media interest in reproduction is evident with the first children born after a uterus transplant, and the first birth following mitochondrial replacement therapy.⁷⁴ Long-term studies as well as ongoing public interest and curiosity is problematic due to invasion of privacy, loss of confidentiality, and for singling these

71. '6.5 million IVF babies since Louise Brown' 5 July 2016, *Focus on Reproduction*: <https://11focusonreproduction.eu/2016/07/0516-5-million-ivf-babies-since-louise-brown/>; an example of the recent discussion of fertility add-on is the Progress Educational Trust public event 'Fertility treatment add-ons: do they add up?' · 29th March 2017, London <http://www.progress.org.uk/addons> (accessed 15 May 2017).
72. For example V Ward 'Louise Brown the first IVF baby, reveals family was bombarded with hate mail' *The Telegraph* 24 July 2015. '<http://www.telegraph.co.uk/news/health/11760004/Louise-Brown-the-first-IVF-baby-reveals-family-was-bombarded-with-hate-mail.html> (accessed 15 May 2017).
73. S Hall 'Louise Brown, first test tube baby, is pregnant' *The Guardian*, 11 July 2006: www.theguardian.com/science/2006/july/11/medicineandhealth/lifeandhealth (Accessed 15 May 2017).
74. C Johnston, 'Womb transplant birth worth the risk, says mother' 4 Oct 2014: www.theguardian.com/lifeandstyle/2014/oct/04/womb-transplant-worth-risk-mother-baby-boy-vincent; J Hamzelou 'Exclusive. World's first baby boy born with "3 parent" technique' *New Scientist* 27 Sept 2016: <https://www.newscientist.com/article/2107219-exclusive-world's-first-baby-born-with-new-3-parent-technique/> (Accessed 9 December 2017).

children out and making them feel different. Confidentiality and privacy are valued and protected by the courts in reproductive as well as other scenarios.⁷⁵ In considering the welfare of future ecto-children and the risk of significant harm, account must be taken of the risk of psychological harm.

Admittedly, the initial interest will likely fade as ecto-children become more common, as it did for children born as a result of IVF procedures. So it is the first ecto-children who are most at risk of psychological harm due to intense interest. Whilst the initial media interest may wane, ecto-children will be subject to long-term studies. These studies are in societal best interests, as well as of medical interest; equally, they may benefit the ecto-children themselves. Participation in long-term studies should identify any problems that ecto-children may have, whether physical, mental or social issues, and support and treatment can be provided.⁷⁶ Involvement in well-run long-term studies may also make ecto-children feel special and encourage participation.

Is psychological harm a risk for ecto-children born later on? Imagining that all ecto-children will be enrolled into studies that follow them throughout their lives, these studies may be perceived by some children as an intrusion and psychologically harmful, thereby impacting their welfare. Beyond this, the only foreseeable psychological harm that may affect ecto-children specifically is any harm that is due to gestation in an artificial uterus. The effect of the artificial uterine experience is unpredictable. Whilst this article approaches ectogenesis as if it were an established procedure, it is only through long-term studies that we will know the impact of the uterine experience.

Uterine experience

Is a future child's welfare maximised through gestation in an artificial uterus? There is a stark difference between those early babies born as a result of IVF procedures and the first children who may be born as a result of complete ectogenesis, not least because IVF babies were gestated within the female uterine environment, just like every other person who has ever existed on this planet. Once conceived and successfully implanted into a female uterus, gestation has progressed naturally, whereas ecto-children will never be gestated within the female uterine environment.

Scientific interest and research will continue whilst attempts are made to improve, maximise, and control the artificial uterine environment. Attempts will be made to mimic the female uterine environment but, as Coleman notes, 'Without knowledge of the exact effects of the maternal

75. For example, the right of under 16s to confidentiality when seeking reproductive advice and treatment: *R (on the application of Axon) v Secretary of State for Health and the Family Planning Association* [2006] EWHC 37 (Admin); the use of super-injunctions: *PIS v News Group Newspapers Ltd* [2016] UKSC 26 in which the privacy interests of the children of the party applying for the injunction were also considered by the court

76. Note the ongoing longitudinal studies with families formed by reproductive donation conducted by S Golombok and team at the Centre for Family Research, Cambridge, for example S Golombok, E Ilioi, L Blake, G Roman and V Jadva, 'A longitudinal study of families formed through reproductive donation: Parent-adolescent relationships and adolescent adjustment at age 14', [2017] *Developmental Psychology*.

environment on the foetus, it would seem that it would be necessary to try to mimic the entire uterine experience'.⁷⁷ Replication is necessary for the ecto-child as the female uterine experience is a proven method of reproduction; women have been successfully reproducing since before time immemorial.⁷⁸

The experience of ecto-children not being gestated inside a woman's body, as well as removing any possibility of bonding with a gestating woman, is unknown and unknowable. Although a woman who acts as a surrogate gives up a child for others to raise, that child has still been carried in a woman's uterus within her body. Ber notes that, 'Although there is no scientific data to prove or disprove it, there are very many anecdotal claims, from women from various cultures and ethnic groups, for the

existence of gestational bonding'.⁷⁹ Tieu discusses the different studies that point to the importance of the maternal-foetal/ newborn bond in the context of surrogacy, and states that 'Therefore, at the very least, one ought to be concerned with any process that disrupts the important bonding between mother and child which begins during gestation and continues after birth'.⁸⁰ Tieu argues against surrogacy arrangements due to the disruption in the bonding that may occur during pregnancy and this can be extended to complete ectogenesis. Naturally gestated children experience a feminine uterine environment, whereas ecto-children will *never* experience this. With complete ectogenesis, the opportunity for bonding between the gestational woman and the foetus is completely removed.

In contrast, Smajdor is dismissive of the gestational mother / foetus bonding as a possible obstacle to complete ectogenesis. She states that love for a child does not rely upon gestation of that child, as fathers, step-parents, and adoptive parents (and I would add intended parents) can love their children as much as gestational mothers do.⁸¹ She also notes that gestating a child '... does not guarantee a secure and unconditional flow of motherly love. Plenty of women fail to bond with their naturally born children'.⁸² Smajdor's conclusion that 'Physical gestation of a child is thus neither necessary nor sufficient for the development of a loving parental bond' is not disputed.⁸³ Nonetheless, Smajdor fails to consider that many women do feel that they have bonded with their child during gestation; neither does she consider the effect upon the future ecto-children who will *never* be carried within a woman's body.

Far more scientific research needs to be conducted before we 'are able to understand the physical and mental effects that the feminine uterine environment has. upon the developing foetus. It is possible that we may never fully comprehend it. The physical mechanics of pregnancy are better understood today than even a couple of decades ago. Furthermore, we better understand the stages of conception, implantation, pregnancy and birth from a medical perspective. Yet we cannot say that we completely

77. Coleman, Note 12 above, at 44.

78. Time immemorial is legally taken as 1189 although women have of course been reproducing and gestating for far longer!

79. R Ber, 'Ethical issues in gestational surrogacy' *Theoretical Medicine and Bioethics* (2000) 21, 153-169, at 155.

80. MM Tieu, 'Altruistic surrogacy: the necessary objectification of surrogate mothers' (2009) *Journal of Medical Ethics* 35, 171-175 at 171.

81. Smajdor, Note 2 above, at 343.

82. *Ibid.*

83. *Ibid.*

understand the whole reproduction process from a physical and psychological perspective for both the future child and the gestating woman. Without sufficient understanding, it is difficult to show that alternatives are an improvement. What is known is that natural gestation is largely successful.

To date, everyone has been gestated within a woman's body. Every person has been cocooned within a woman's body, experiencing many different stimuli. Whilst premature babies have limited experience of the female uterine environment, they have still had some experience. Science may one day be able to recreate the physical structure of the female uterus, and provide sustenance in this artificial environment, but it is unlikely to ever be able to truly replicate the experience of gestation within the female body.

There will undoubtedly be efforts to replicate the female uterine environment. Within the laboratory, different levels of light will mimic the hours of the day / night, music and television will be played and different nutrients provided to simulate input from food. The optimum inputs may not be determined until years later, once follow-up studies have been conducted upon multiple ecto-children. Ecto-foetuses may react to different stimuli that are harmful to their physical and mental health and this may only become apparent after birth. For this reason, long-term follow up studies are vital in order to minimise any risk of harm to the future ecto-children. As noted previously, follow up studies should benefit ecto-children through appropriate treatment and support for any identified problems. In taking account of the welfare of the future child; I recommend that one must consider the uterine environment, potential impact upon the future child, and any risk of significant harm. This is already partially demonstrated through the HFEA Code of Practice that requires consideration of drug or alcohol abuse, demonstrating that the proposed uterine environment may be harmful to the future child.⁸⁴

Experiences and stimuli will be uniformly applied to all ecto-foetuses. The laboratory environment would be a controlled sterile environment; replication of proven medical procedures is standard practice. We would have ecto-children born with the same gestational experiences: is this a significant risk of harm to their welfare? Fear of the unknown may not be a good reason not to pursue something, but when we are playing with future people's lives there needs to be a good reason to choose complete ectogenesis as a method of reproduction. I argue that it needs to be shown that it is in the best interests of the future ecto-children that they are conceived and gestated in this way, and that the welfare of future ecto-children has been fully contemplated prior to embryo transfer to an artificial uterus.

Although it may be medically possible to create and gestate *ex utero*, the long-term impacts of the uterine environment are unknown. As such, the welfare of future children is not protected through the use of complete ectogenesis.

84. Factors, Code of Practice, HFEA, version 3.0, 8.10 (b)(ii): <https://www.hfea.gov.uk/code-of-practice/8#section-header>.

Whilst it may be possible to provide appropriate stimuli that do not physically harm future ecto-children, the uniform application of stimuli in the uterine environment could impact our uniqueness. Genetic make-up is a vital part of our individuality; in the same vein, the gestational experience is unique to every one of us and helps to shape who we become. If we standardise stimuli for all complete ecto-foetuses, we run the risk of losing some of the uniqueness of our humanity. There is much discussion around the nature vs nurture argument, but we cannot ignore how little we know about the uterine environment, and its effect upon us as developing humans. Even if complete ectogenesis is established as a safe way to reproduce, that produces physically healthy individuals, the uterine experience effect will take decades to establish. These arguments have been raised previously with respect to human reproductive cloning, and the risk of harm to future clones is one reason why human reproductive cloning is outlawed in many countries.⁸⁵ The loss of uniqueness argument is strengthened when we consider the possibility of human reproductive cloning in conjunction with artificial uteruses. When considering the use of complete ectogenesis and the uterine experience, the welfare of future ecto-children must be taken into account. The lack of knowledge of the uterine effect, and the potential for significant impact upon the welfare of the resulting ecto-children, is sufficient justification to prevent the use of complete ectogenesis for reproductive purposes.

Legal parenthood

Importantly, questions around legal parenthood would have to be addressed at a legislative level before either research trials or treatment could commence. It is currently accepted that it is a fundamental right of children to know who their legal parents are, and legal parents to know what their own rights and responsibilities are.⁸⁶ The continuing acceptance of the importance of legal parenthood requires forward thinking of the implications and ramifications of complete ectogenesis for legal parenthood. Whilst this article is predominantly reflecting upon ectogenesis as a reproductive treatment, it is necessary to establish who is a legal parent during research trials, as well as who is a legal parent when complete ectogenesis is used for reproductive treatment. The future ecto-child's welfare requires someone to make decisions on its behalf, to consider its best interests, and to provide security upon birth. Without determination of legal parenthood, this would fall to the court and create an unnecessary burden. It is proposed that legal parenthood will differ in the two circumstances.

85. DG Jones and KA Galvin, 'Principles of health care ethics' in RE Ashcroft, A Dawson, H Draper and J McMillan (eds) *Human reproductive cloning* (2nd ed) (Wiley, 2007) ch 102; RM Isasi and BM Knoppers, 'Mind the gap: policy approaches to embryonic stem cell and cloning research in 50 countries' (2006) 13(1) *European Journal of Health Law* at 9-25.

86. For example, refer to the case that helped to change the rules on donor gamete anonymity: *R (on the application of Rose and another) v Secretary of State for Health and Another* [2002] EWHC 1593 (Admin).

Currently, when ascribing legal motherhood, considerable weight is given to gestation, as the birth mother is always the legal mother.⁸⁷ It is only upon the grant of a parental order (for surrogacy arrangements) or an adoption order that legal motherhood is transferred to another.⁸⁸

Whilst gestation plays an important role in parenthood, the courts have recognised that parenthood includes other roles, including social, psychological and genetic.⁸⁹ Alongside the intention to procreate, these different roles will receive greater prominence due to the absence of a birth mother.

Legal parenthood determines who is responsible for a child after birth, thereby giving the child security. As with other reproductive research, complete ectogenetic research will involve the use of donated gametes and embryos. Gamete and embryo donors currently revoke all rights, responsibilities and ownership upon donation, although a register must be kept.⁹⁰ As such, scientists and research ethics committees will need to establish who will have legal parenthood and responsibility for any ecto-foetuses that survive ecto-gestation and birth during a research trial.

Whilst gestation and intention to become parents are driving forces behind the parenthood provisions with natural pregnancies, neither of these is a factor in complete ectogenetic research. Likewise, social, psychological and genetic parenthood will not initially be factors that can assist in determining legal parenthood of ecto-children born as a result of a research trial. It is therefore suggested that a period of consultation and debate is needed, resulting in legislative provisions to determine legal parenthood. One recommendation for debate is an appointed guardian with legal responsibility to make decisions on behalf of the ecto-foetus both during and after birth, including medical, educational, and caring decisions (such as adoption). Financial responsibility requires further debate, as a number of different people could be financially responsible for ecto-children until it is determined who is to have long-term legal responsibility.⁹¹

In complete ectogenetic reproductive treatment an appointed guardian is not necessary. Instead, it is recommended that legal parenthood provisions be enacted to reflect intended parenthood. Intended parenthood is recommended as the appropriate model, as a complete ectogenetic gestation will not commence without someone requesting it. Whether a single person or a couple, those who embark on ectogenetic services should have legal parenthood, so long they meet the relevant criteria that reflect the current arguments around legal parenthood in surrogacy agreements.⁹² As in a surrogacy agreement, the ecto-foetus would not come into existence without the actions and express agreement of the intended parent(s). It is in the future ecto-child's best interests to have legal parent(s); without legal parent(s) there is a significant risk of harm, including psychological harm.⁹³ In addition, if donor gametes are

87. Human Fertilisation and Embryology Act 1990 (as amended), section 33.

88. Ibid, section 54; Children and Adoption Act 2002, section 46.

89. In *Re G (Children)(Residence: same-sex partner)* [2006] UKHL 43, per Baroness Hale at paragraphs 33 to 36.

90. Human Fertilisation and Embryology Act 1990 (as amended).

91. For example, it could be the principal investigator of the research trial, the funding body, the appointed guardian, or the State.

92. For example, refer 'to K Horsey, 'Fraying at the Edges: UK Surrogacy Law in 2015: *H v S (surrogacy Agreement)* [2015] EWFC 17, *Re Z (A Child: H11111an Fertilisation and Embryology Order)*[2015] EWFC 73, A & B (*Children*)(*Surrogacy: Parental Orders: Time Limits*) [2015] EWHC 911 (Fam)' (2016) *Medical Law Review* 24(4) 608-621 at 621.

93. Developmental deficiencies and psychological harm are apparent in children raised in institutional settings, without permanent parents. RB McCall, 'Research, Practice, and Policy Perspectives on Issues of Children without Permanent Parental Care', [2011] *Monographs of the Society for Research in Child Development* 76(4) at 223-272.

used for reproductive treatment, the donors will not have legal responsibility for any resulting ecto-children. Legal parenthood provides children with security surrounding their family situation. This has been consistently recognised by the courts.⁹⁴

Without legal consensus and recognition of parenthood of ecto-children, they risk significant harm. If no one has legal responsibility for ecto-children there is no one to consent to medical treatment, make decisions about education or living arrangements, or to be financially responsible. The state can step in to care for and make decisions for children, yet this is an unnecessary burden upon state resources when ecto-children are desired, and there are intended parents who want to be legally recognised as parents.

Complete ectogenesis may be an opportunity to re-think, re-imagine, and re-draw the lines of legal parenthood. Today's society acknowledges the need for children to know their parents ... biological, legal and gestational. The need to know one's own parents has been recognised by the courts as being in the best interests of children on multiple occasions and legal parenthood is at the heart of parental order applications following surrogacy arrangements.⁹⁵ Assuming that ectogenesis does not change the fundamental belief that it is every person's right to know their biological and legal parents, we would need to ensure that this continues through legislative provisions.

Termination of ecto-gestation

Whilst embryos / foetuses do not have legal rights until birth, in the United Kingdom we do accord a special status to the human embryo / foetus.⁹⁶ Accordingly, UK law protects the *in vitro* embryo. up to 14 days' development by permitting research in defined and limited circumstances.⁹⁷ The embryo / foetus *in utero* is also protected from termination except in defined circumstances that become more restrictive after 24 weeks' gestation in recognition that the foetus may be viable.⁹⁸ There is, however, a moral and legal difference between an early embryo *in vitro* and an early embryo *in utero*. Whilst the early embryo *in vitro* is protected in the sense that we are not able to do whatever we wish with it, it is only once an embryo is transferred to the female uterus that we treat it with greater respect.⁹⁹

94. For example, *Re X (A Child)(Surrogacy: time limit)* [2014] EWHC 3135 (Fam); *Re A (A Child)* [2015] EWHC 911 (Fam).

95. For example, *X (A Child)*, Note 94 above; *A & B (no 2 - Parental Order)* [2015] -EWHC 2080 (Fam).

96. First formally recognised by the report of the Committee of Inquiry into Human Fertilisation and Embryology, Department of Health (1984) Cmnd 9314 (the Warnock report). The special status of the embryo/foetus was enshrined in UK legislation in the Human Fertilisation and Embryology Act 1990 (now amended). Read alongside the Abortion Act 1967 it is clear that UK law takes a gradualist approach towards the human embryo/foetus. See Hammond-Browning, Note 47 above.

97. Human Fertilisation and Embryology Act 1990 (as amended), Schedule 2, paragraph.3.

98. *Ibid*, section 3(3)(a) and 3(4) and Abortion Act 1967, section 1(1)(a)=(e).

99. Hammond-Browning, Note 47 above.

The transfer to the female uterus is significant, as it is from this moment that the early embryo has the opportunity to exercise its potential; it is within the environment necessary for development, and ultimately birth. Legal termination is permitted in limited circumstances due to the potentiality and viability of the developing embryo/foetus *in utero*, although this is balanced with the needs of the gestating woman and respect for her bodily autonomy.

A gestating woman is usually able to make decisions regarding the pregnancy, taking into account her own health needs and interests. Although she may be morally responsible to the foetus that she is carrying, legal parenthood of the foetus is not recognised until birth. She is able to make decisions regarding the pregnancy on the basis that any treatment requires her consent as it affects her body. With the lack of a gestating woman in complete ectogenesis legal parenthood needs to be recognised from conception, so that someone can make decisions regarding the ecto-gestation and the ecto-foetus. Whilst the focus of this article has been upon the welfare of future ecto-children it would be remiss to exclude completely discussion around termination of an ectogenetic gestation. This is different from the separation argument that partial ectogenesis would negate the need for termination of pregnancy because, perhaps controversially, there may be situations when the risk of significant harm to the future ecto-child justifies termination.¹⁰⁰

Whilst I have concentrated on ectogenesis as a reproductive treatment, it is important to note that termination of ecto-gestation may be desired, or needed, during research trials should something go wrong in the development of the ecto-foetus. An ecto-foetus may be affected by severe and profound disabilities, in which it could be argued that termination would be preferable to birth and a (short) life of suffering.¹⁰¹ In the research trial scenario, as previously recommended, the appointment of a guardian would assist, as the guardian could consent to termination of the ecto-gestation. Termination may happen frequently (if ethically and legally permitted) in the early stages of the research, as scientists will want to examine how the ecto-embryo / foetus is developing. Legal reform of the Abortion Act 1967 would be needed in order to allow termination on research grounds, as this moves beyond the therapeutic grounds currently permitted in the Act, and is completely removed from the reasons for which a termination is legally permitted. However, I suggest that new legislation is needed to permit termination of ectogenetic gestation for research purposes. The moral grounds and debate for termination are beyond the scope of this article, although I recognise that termination for research purposes goes far beyond the terms of the Abortion Act and would require extensive and thorough ethical consideration. Nevertheless, this would not be novel territory, as legislation permits the *in vitro* use and subsequent destruction of embryos for research purposes.¹⁰²

100. Singer and Wells, Note 7 above. For a critique of the severance theory, see Cannold, Note 11 above.

101. For example, anencephaly.

102. Human Fertilisation and Embryology Act.1990 (as amended), Schedule 2.

If malformed embryos or severely disabled fetuses were produced in research trials, termination of the ecto-gestation would be legally permissible under the Abortion Act 1967. Termination can be justified, as it may be preferable to living a life of pain and suffering; termination therefore avoids significant risk of harm to the ecto-foetus.¹⁰³ I recognise that many may not share this viewpoint; however, terminations do occur on grounds of foetal disability. There are some who would prefer to terminate the pregnancy, considering that it is better never to exist than to give birth to and raise a child that lives a life with a disability.¹⁰⁴

Although I have argued that complete ectogenesis is not in the best interests of future ecto-children as there is a significant risk of harm, it is foreseeable that it will be developed. As previously discussed, when complete ectogenesis is a reproductive treatment, it is important to establish legal parenthood in order to provide security to future ecto-children. This will also establish who has legal responsibility and decision-making powers during ecto-gestation. Although the ecto-child may be desired, during ecto-gestation a situation may arise where termination is considered and requested by an intended parent. Termination of ecto-gestation is harder to justify when the ecto-foetus is developing without medical problems. The Abortion Act 1967 permits termination of pregnancy up to 24 weeks on the grounds that '... continuance of the pregnancy would involve risk, greater than if the pregnancy were terminated, of injury to the physical or mental health of the pregnant woman or any existing children of her family'.¹⁰⁵ If we were to replace 'pregnant woman' with 'intended parent' this ground could permit termination of an ecto-gestation if there is risk to the *mental* health of an intended parent (risk to the physical health of an intended non-gestating parent is a situation that is harder to contemplate). Equally, any existing children need to be accounted for under this ground, thereby permitting legal termination of an ecto-gestation if the interests of any existing children of the family might be harmed. Only if medical problems or disability of the ecto-foetus are taken into account might it be argued that the welfare of the ecto-foetus is considered and termination justified under section 1(1)(d) Abortion Act 1967.

The issue arises as to who can consent to the termination. Where there is more than one intended parent, the parenthood provisions should determine what is to happen if there is disagreement. If needed, the court could enforce those provisions. Alternatively, a contractual arrangement determining situations when termination will occur, could be drawn up prior to commencing conception. The UK history of regulating reproduction suggests that legislation is the most likely scenario and this would need to take

103. I note that there is considerable debate around termination on the grounds of disability. A useful critique is S McGuinness, 'Law, reproduction, and disability: fatally "handicapped"?' (2013) *Medical Law Review* 21(1) 213-242.

104. Statistics show that terminations for reasons of disability do occur, although I also note that the reason behind the decision is not recorded, so there will be some who terminate for reasons other than not wanting a child with a disability. In 2016, 3208 pregnancies were terminated under the disability ground: *Abortion statistics, England and Wales: 2016* (Department of Health, 2017): https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/652083/Abortion...statsEngland_Wales;2016.pdf (accessed 11 January 2017).

105. Abortion Act 1967, section 1(1)(a).

into account the welfare of the future ecto-child. This may make it harder to justify termination of an ecto-gestation due to the separation of gestation from the female body. Men will have a stronger voice than they currently have with regards to termination of pregnancy within the female body- an equal status regardless of gender would be advocated although the exact provisions to resolve conflict need careful drafting.¹⁰⁶

In determining if termination is in the best interests of the ecto-foetus, foetal interests post-birth should also be factored in. If the intended parents will abandon (or have already abandoned) the ecto-child, is adoption or foster care the most appropriate option? Social care resources are limited and may be unable to cope with more children. There is evidence that only 'desirable' children are adopted.¹⁰⁷ If there is public distrust of the long-term effects of ecto-gestation then it may be very difficult to find suitable carers.

It is clear that debate is needed now to determine appropriate provisions to regulate termination of ecto-gestation, to debate and enact proactive regulation that governs when termination can occur, consent provisions, and how to resolve disagreements between intended parents.

Conclusion

This article has sought to examine partial and complete ectogenesis from the perspective of the future children. Foetal transfer from a female uterus to a complex artificial uterus may be justified when it benefits the welfare of the particular foetus. These are situations where the foetus' opportunity for life is maximised, through removal from a toxic environment (substance abuse), a potentially toxic environment (medical treatment), or to a more easily accessible environment that allows medical treatment of the foetus in utero. These situations also benefit the gestating woman, but it is important that the foetus' best interests are also maximised through foetal transfer. In contrast, complete ectogenesis, even after it is proven to be a physically safe method of reproduction, cannot be shown to benefit the welfare of future ecto-children. Whilst science may be able to replicate the female uterine environment, the long-term effects of complete ecto-gestation will not be known for decades and the risk of harm is too high, particularly when the female uterus is a proven method of reproduction. In light of these issues, it is not yet shown that the pursuance and use of complete ectogenesis as a reproductive technology benefits the welfare of future ecto-children. Therefore, I argue that due to the significant risk of harm there is no benefit to future children to be conceived and gestated entirely outside of the female body.

106. Men currently have no rights in respect of termination of pregnancy: *Paton v BPAS* [1979] QB 276. It can be argued that men do have a strong say in respect of disagreements over embryos, even where the female partner had no other options to reproduce her own genetic child: *Evans v Amicus Healthcare Ltd and Others* [2004] EWCA Civ 727.

107. K O'Halloran, *The Politics of adoption* (Springer, 2015), chapter 2: 'The changing face of adoption in the United Kingdom', at 47.

Some of the arguments presented here are speculative. Ho has argued that 'Speculations are not sufficient. We need evidence to establish the dangers of ectogenesis and we will not know what they are until it becomes a reality ... Ectogenesis is merely a point in the history of medical progress'.¹⁰⁸

However, I argue that speculation is sufficient when it involves the ramifications of developing complete ectogenesis. I have argued elsewhere that 'The slippery slope snake has reared its head in respect of many novel scientific developments ... and thus ... is not a novel argument'.¹⁰⁹ However, I have also argued that concerns must be raised and addressed and within the United Kingdom many fears '... have not materialised, probably due to the controlled regulatory environment that exists in the UK'.¹¹⁰ As such, the regulation of ectogenesis must be considered, in conjunction with welfare, harm and best interests of future children. A proactive approach to regulation is needed, as ectogenesis raises issues that current regulation did not consider during its drafting and subsequent implementation. I have raised concerns around pain and suffering of future ecto-children, psychological impact, the uterine experience, legal parenthood and termination, and how these situations may be interpreted and applied within current legislative provisions. Well-debated and sound regulation that takes all of these issues into account is absolutely necessary, and it must incorporate the welfare of the resulting children.

108. D Ho, 'Leaving people alone: liberalism, ectogenesis, and the limits of medicine', in Gelfand and Shook, Note 3 above, at 145.

109. Hammond-Browning, Note 47 above, at 597.

110. Ibid .