Emerging Areas of Personalized Medicine in Obstetrics & Gynaecology: A Narrative Review

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Abstract

IMPORTANCE: The focus of obstetrics and gynaecology (OBGYN) is women's reproductive health. Many significant challenges in the field of OBGYN stem from limitations in screening, diagnostic, or treatment options. Conditions that are poorly understood, such as pre-eclampsia or endometriosis, offer few management options or prevention strategies. In recent years, growing interest and advancements in personalized medicine have led to a deeper understanding of the aetiology and pathophysiology of OBGYN conditions, potential targets for intervention, and novel approaches to management. The aim of this review is to briefly describe some of these emerging areas of research and clinical uses.

OBSERVATIONS: Personalized medicine in obstetrics is a foundational concept underlying routine prenatal care. It also drives ongoing research in areas such as advanced assisted reproductive technology, screening for medical complications during pregnancy, and in utero foetal treatment of congenital diseases. In gynaecology, developments in our understanding of the determinants and mechanisms of conditions such as endometriosis and menopause have illuminated potential avenues for improved diagnosis and more individualized approaches to treatment.

CONCLUSIONS AND RELEVANCE: Personalized medicine in OBGYN is a flourishing area of research with the potential for significant clinical benefits. Ongoing research into OBGYN disease processes that are poorly understood are beginning to identify potential novel diagnostic and treatment options for the future. With endless potential to improve the health outcomes of women and children, personalized approaches to screening, diagnosis, and management are worthwhile investments.

Introduction

Obstetrics and Gynaecology (OBGYN) is the field of medicine that focuses on women's health, including pregnancy and its associated complications, childbirth, and conditions involving the reproductive organs. As the field of personalized medicine has grown across all areas of medicine, advancements specific to OBGYN have also been developed into novel or potential clinical applications. Personalized medicine eschews the presumption of a "one size fits all" management approach and aims to develop individualized and targeted therapies for patients by understanding and leveraging the pharmacogenomic, biological, and environmental determinants of a condition.

A better understanding of the aetiology and pathophysiology of conditions in OBGYN have led to exciting potential applications for personalized medicine in OBGYN. For example, two areas of focus for personalized medicine in OBGYN include infertility and gynaecological cancers. According to the World Health Organization, 10 to 15% of couples worldwide experience infertility in their lifetime[1]. Meanwhile, 70% of in-vitro fertilization cases fail per cycle in the United States[2]. Personalized medicine in advanced assisted reproductive technologies (ART) is an emerging area of focus aimed at improving these outcomes[3,4]. Genetic subtyping of gynaecological cancers is another potentially significant area for personalized medicine in OBGYN. Treatments tailored to a

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patient's genetic subtype have been shown to improve survival outcomes when used in conjunction with traditional chemotherapy[5]. In this narrative review, we briefly explore in greater detail some of the existing applications of personalized medicine in OBGYN and emerging areas of research.

Personalized Medicine in Obstetrics

A personalized, multi-modal approach to routine obstetric care combines patient characteristics, advanced imaging, and genetics for early detection of foetal pathologies and risk stratification during pregnancy. For instance, the combination of maternal factors with ultrasound-based parameters, including estimated foetal weight and uterine artery pulsatility, is used to identify antenatal pregnancies at risk for small for gestational age (SGA) neonates. This allows for early monitoring of SGA foetuses and determines the appropriate frequency of follow-up assessments[6]. Individual patient factors are also increasingly used in advanced ART to increase success rates and prevent foetal disease. One example is pre-implantation embryo genetics, which involves genetically testing embryos for chromosomal abnormalities before implantation, allowing for medical decisions and interventions tailored to the genetic characteristics of the individual(s)[7]. Non-invasive perinatal testing during pregnancy can identify chromosomal abnormalities, copy number variants, or single nucleotide polymorphisms (SNPs); furthermore, whole genome sequencing of maternal blood is an effective indicator of aneuploidies[8,9] and monogenic diseases such as beta-thalassemias[10]. Similarly, comparing foetal DNA to the SNPs on existing electronic records is useful for the prediction of gestational diabetes before its onset[11].

Identifying maternal biomarkers is another tool used for the early detection and treatment of obstetric diseases in utero. One study demonstrated that altered angiogenic biomarkers, placental growth factor, and soluble fms-like tyrosine kinase 1 (sFlt-1) can be used as indicators of pre-eclampsia, hypertensive disorders during pregnancy, and foetal growth restriction[12]. Another paper described the potential for in utero precision gene-editing in sickle cell disease[13]. Improvements in diagnostic precision are also paving the way for early and targeted interventions in obstetrics, with tools such as nanotechnology and exosomes[14].

Dedicated research centres such as the Irish Centre for Maternal and Child Health Research (INFANT) are leading the frontiers of personalized medicine research in OBGYN to address knowledge gaps, quality improvement, and the clinical experience of parents[15]. For example, the Pregnancy Loss research group was awarded the HSE Open Access Research Award for qualitative research on antenatally-diagnosed fatal foetal anomalies and the experience of parents[16]. Taking a personalized approach to obstetric care has positive implications for disease prevention, detection, and treatment, leading to better maternal and foetal outcomes.

Personalized Medicine in Gynaecology

Recent advances in technology have fuelled research into personalized approaches in the diagnosis, prognostic prediction, and treatment optimization of gynaecological conditions[17]. For example, computer-aided histopathologic characterization of endometriotic lesions may lead to improved diagnostic and prognostic accuracy of endometriosis. In one study, the use of a specialized form of mass spectrometry coupled with statistical modelling enhanced the classification of endometriotic lesions with 98.8% accuracy[18]. Another study quantified cytokeratin and CD10 markers in epithelial and stromal cells from excised endometrial lesions and found a correlation between total endometrial cells and pain ratings[19]. These developments in endometriosis research contribute to better identification of disease mechanisms. According to Dr. Mette Nyegaard, a professor of Personalized Medicine at Aalborg University, these advancements could “pave the way for enhanced risk prediction tools and the emergence of personalized treatment options”[20].

Personalized medicine also plays a role in assessing the risk and candidacy for hormonal therapy in postmenopausal women. The Women's Health Initiative in the United States has suggested that a woman's individual characteristics, including age, time since menopause, symptom severity, and genetic predisposition can influence the efficacy of hormonal

therapy[21]. The concept of personalized medicine in the management of menopause aims to identify women who are more likely to benefit from hormone therapy and allows for tailored treatment approaches that enhance efficacy and safety. Additionally, incorporating patient-centred outcomes such as quality of life into the clinical decision-making will further enhance the care provided by gynaecologists managing menopause. When considered in the risk-benefit ratio, these individualized factors have been shown to directly impact treatment compliance of hormonal therapy[22].

Future Directions

Women's health has advanced substantially throughout the 21st century with increased research interest in OBGYN conditions[23]. As such, there are many exciting new technologies being investigated to allow for personalized care. For example, novel personalized contraception that is reliable, affordable, requires fewer medical visits, no procedures, and provides women with more control over their contraceptive care are being developed. These include a once-a-month pill, micro-array patch, and a 6-month injection[24]. Another example of an innovation that will improve safety for mothers and new-borns is an artificial intelligence (AI) powered portable ultrasound machine[25]. Many wealthy countries and hospitals have the staff and resources to scan and interpret results for pregnant mothers; under-resourced areas or rural communities may not have access to these same resources. AI powered ultrasound technology could provide the imaging assessments necessary in resource-limited areas and guide the appropriate management of obstetric complications[25]. As more funding and research is directed towards personalized medicine in women's health, we will see advancements in conditions that are difficult to identify and treat, thus improving reproductive health for women globally.

Conclusion

Interest in personalized medicine has led to advancements across all areas of medicine, resulting in targeted diagnsostic and management approaches. Within OBGYN, progress manifests in heighted success rates in assisted reproductive technologies, screening and diagnostic test accuracy in significant obstetric complications, enhanced accuracy of screening and diagnostic tests for significant obstetric complications, and novel therapeutic modalities for challenging conditions. With time, the impact of personalized medicine in OBGYN will only enhance reproductive care and contribute to better outcomes in women and children's health.

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