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AI in the Delivery Room: Shaping the Future of Childbirth

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Abstract

Background. Artificial intelligence (AI) is defined as the application of advanced algorithms and machine learning techniques to analyze large amounts of data. Its use in medicine concerns areas such as medical images, laboratory test results, and patient medical histories. Thanks to its predictive capabilities, AI can also forecast the risk of diseases, identify patterns in data, and discover new relationships, which can lead to better healthcare, faster diagnoses, and more effective therapies.

Aim. This study reviews current applications of artificial intelligence in obstetrics, highlighting its benefits in routine tests like ultrasound and its impact on IVF procedures.

Material and methods. The studies cited in the presented review were selected from PUBMED.The oldest article is from 2017, while the most citations come from articles from 2023. The key words used for the search included: 'artificial intelligence' and 'obstetrics'. Articles not written in English were excluded.

Results. In obstetrics, artificial intelligence has applications in many examinations used on a daily basis, such as ultrasound or cardiotocography. In addition, it is also used, among other things, to analyse fetal heart echocardiography films and calculate the deviation from normal. Other uses of artificial intelligence can be seen in imaging methods such as MRI. The impact of this technology in the in vitro procedure should be noted as well.

Conclusions. AI technology will possibly bring opportunities for better medical care in obstetrics. It will enable better diagnosis and more effective treatment. It also brings an opportunity for the development of better treatments for infertility in women.

Key words: artificial intelligence, diagnostic possibilities, IVF, obstetrics, treatment.

1. Introduction

Artificial intelligence (AI) refers to the use of complex algorithms to perform cognitive functions, make decisions, and execute advanced tasks using appropriately designed machines [1]. In medicine, AI has rapidly expanded, particularly in managing large datasets, analyzing complex algorithms, and addressing medico-legal concerns [2]. In gynecology and obstetrics, AI is primarily applied to imaging studies such as ultrasound and MRI. Algorithms are trained to classify the placenta and fetal organs automatically. AI also supports the prediction of preterm birth through analysis of health record databases, fetal weight estimation, and the use of automated cardiotocography systems to detect fetal heart pathologies before delivery [3-5]. Additionally, AI is used in IVF to select optimal oocytes and sperm, and to assess the developmental potential of resulting zygotes [6]. Overall, AI offers valuable support in complex diagnostic decisions and may enhance treatment outcomes and patient survival [7]. This is especially desirable in obstetrics, a specialization recognized as one of the most litigious among patients - according to statistics from 2017-2018, 48% of payouts were related to obstetric negligence [1,4].

2. Research materials and methods

For this review on Artificial intelligence in Obstetrics, published in the English language between 2017 and 2023 were identified. Literature research was performed using PubMed, an online database including 1100 citations for biomedical literature using the following keywords: artificial intelligence and obstetrics. In addition, we used search terms for tasks associated with AI and obstetrics such as diagnostic possibilities and treatment as cross reference. For the current review, the following inclusion criteria were specified:

1. The articles include current developments, clinical practice and new possibilities of AI in obstetrics.

2. The articles taking into account the advantages and disadvantages of this innovative method in medicine.

3. Studies with novel ideas and in-depth research.

Forty-three studies were eventually selected from the articles found for review. Articles were excluded after reviewing the papers because they did not meet our predefined inclusion criteria, while others that initially met the criteria were disqualified because they were not available in full or were not in English.

3. Research results

3.1. Artificial Intelligence And Its Development In Medicine

Artificial intelligence (AI) was introduced in the 1960s to simulate human intelligence using computers [8]. The four fundamental elements that make up artificial intelligence are machine learning (ML), natural language processing (NLP), artificial neural networks (ANNs), and computer vision [1].

AI has seen rapid advancement in diagnostic radiology, including computed tomography (CT), magnetic resonance imaging (MRI), ultrasonography, and pathology analysis [8]. As early as the 1970s and 1980s, AI-supported ultrasound imaging helped diagnose fetal anomalies [3]. AI is also used in 3D printing to create anatomical models for preoperative planning [9].

AI also has the potential to reduce medical errors, which rank as the third leading cause of death in the U.S., by improving diagnostic accuracy and reducing the cognitive burden on healthcare professionals [7]. Furthermore, AI enables real-time access to medical knowledge and supports evidence-based medicine by analyzing vast amounts of clinical data [10]. A survey of 70 medical students at Polish medical universities showed that 90% of respondents supported the introduction of AI into medicine and 87.1% thought it could improve doctors' work and reduce medical errors. The students emphasised the need for AI to be supervised by a supervising physician, who would also be responsible for any errors [11].

The current use of AI in obstetrics includes aspects such as cardiotocography (CTG), fetal heart rate (FHR), ultrasound (USG), magnetic resonance imaging (MRI), determining the risk of preterm birth, and in vitro fertilization (IVF) [9,12].

3.2. Cardiotocography

Cardiotocography (CTG) is a widely used method for monitoring fetal health by assessing fetal heart rate (FHR) and uterine contractions, primarily to predict fetal hypoxia.

However, its interpretation heavily depends on clinicians' experience, leading to increasing interest in AI-based computerized CTG analysis [1,13].

Petroziello et al. applied deep learning, specifically Multimodal Convolutional Neural Networks (MCNN), to predict fetal acidosis. Their model, using FHR, uterine contractions, and signal quality parameters, achieved its best performance (0.77 AUC) when trained on the last hour of labor, outperforming previous automated methods [14]. Similarly, Fergus et al. demonstrated that a deep learning classifier could predict natural births and C-sections with 94% sensitivity and 91% specificity, surpassing clinicians' predictive accuracy [15]. The same author, in another study, introduced a new approach to using machine learning for CTG analysis to overcome limitations associated with skewed class distributions and manual feature extraction. Therefore, this method used a windowing technique, a One-Dimensional Convolutional Neural Network (1DCNN), and a Multilayer Perceptron. According to the research, the suggested framework shows promising results, with a sensitivity of 80% and specificity of 79% [16].

Zhou et al. addressed class imbalance in FHR classification by implementing Edge Clipping and Multiscale Noise (ECMN) data augmentation and a Trend-Guided Long Convolution Network (TGLCN), which improved accuracy to 89.8% [17]. Meanwhile, Das et al. compared multiple machine learning models for detecting FHR decelerations, finding that a Multilayer Perceptron reached 97.94% accuracy when trained with fuzzy logic annotations, while a Random Forest performed best (63.92%) when using clinician annotations [18].

A more advanced AI model, Hybrid-FHR, was recently developed by Zhao et al. This approach integrates multimodal features with a multi-scale squeeze and excitation temporal convolutional network (SE-TCN). By incorporating frequency, time-domain, and nonlinear expert features with a cross-modal feature fusion (CMFF) mechanism, Hybrid-FHR achieved an impressive 96.8% accuracy—showcasing AI’s potential for more precise and early detection of fetal acidosis [13].

3.3. Fetal Echocardiography

Fetal echocardiography is a non-invasive ultrasound examination used to assess the fetal heart [19]. Despite its widespread use, prenatal detection rates of congenital heart disease (CHD) remain low, often due to the heart's small size, structural complexity, and varying skill levels of sonographers [20,21].

Recent studies have explored AI applications in detecting specific fetal cardiac views. Nurmiani et al. developed a deep learning-based segmentation model using Mask-RCNN, achieving high accuracy in identifying key heart structures such as the left and right ventricular outflow tracts (LVOT, RVOT), four-chamber view (4CH), and three-vessel trachea (3VT) [19]. Similarly, Wu et al. introduced U-Y-Net, a model that utilized a YOLOV5 convolutional neural network. As shown, it performed well in detecting significant structures of the fetal heart, with a 94.30% map value. Moreover, this model can classify five standard fetal cardiac views- 4CH, LVOT, RVOT, 3VT, and additionally three-vessel view (3VV) [22].

AI is also being explored as an automated screening tool for CHD. Gong et al. proposed the DGACNN model, integrating a One-Class Classification network with a generative adversarial CNN (GACNN), achieving an 85% accuracy in identifying CHD from echocardiogram video slices [23]. To enhance clinical usability, Sakai et al. developed a deep neural network model with explainable representations, providing sonographers with visualized results that improved screening performance across all expertise levels [24].

Another application of AI can be quantitative analysis of echocardiographic images and performing measurements. Herling et al. introduced an automated method for measuring atrioventricular plane displacement (AVPD) using graphical representations of the velocity of myocardial movement acquired through a technique called color tissue Doppler imaging (cTDI). This approach was compared with measurement using anatomic M-mode, and a significant correlation was found [25].

Recently, Scharf et al. explored the use of an automated technique to measure the myocardial performance index (MPI) to facilitate the evaluation of fetal heart function for less experienced clinicians. Both a novice and a professional conducted measurements of the modified ventricular MPI (RV-Mod-MPI), and the results demonstrated a similar distribution, suggesting that this method could be incorporated into medical practice [26].

3.4. Ultrasound

Obstetric ultrasound is one of the most widely used imaging techniques, yet AI's integration into this field remains limited. AI algorithms assist in analyzing ultrasound images, enabling non-specialists to perform basic scans. Automation of fetal biometric measurements and anomaly detection reduces exam time, physician workload, and improves accuracy [2,27].

Deep convolutional neural networks can detect placental abnormalities associated with hypertensive disorders by analyzing texture patterns in early pregnancy [28]. AI also facilitates the detection of chromosomal anomalies such as Down syndrome by automating nuchal translucency (NT) measurement—often challenging for less experienced operators. Tools like sonoNT and models such as Sciortino's (99.95% accuracy in fetal plane recognition) minimize operator variability and are already integrated into some ultrasound systems, with fully automated versions on the horizon [27].

In gestational age estimation, AI analyzing fetal brain morphology achieved a 95% confidence interval of 14.2 days, improving to 11.0 days when combined with fetal biometry, outperforming traditional methods (12.9 days) [29]. AI also aids in diagnosing fetal growth restriction through craniocerebral volume measurements, though current methods remain semi-automated [21].

AI supports gestational sac assessment and neurodevelopmental evaluation, classifying fetal brain planes and identifying structures like the Sylvian fissure, thalamus, and cerebellum, as well as anomalies such as ventriculomegaly or absent septum pellucidum [21,30-33].

Although current AI applications focus on distinguishing normal from abnormal images, precise identification of specific birth defects remains challenging. For example, absence of the septum pellucidum may suggest corpus callosum agenesis, while an open fourth ventricle may indicate Dandy-Walker malformation [34]. To support diagnostic refinement, structured decision support systems using phenotype databases have been introduced [35].

3.5 Magnetic Resonance Imaging (MRI)

A great breakthrough in the development of medicine was also the application of artificial intelligence in fetal magnetic resonance imaging (MRI). Abnormalities of the fetal central nervous system are quite common, occurring in 0.1% to 0.2% of live births and in 3% to 6% of stillbirths, so it is crucial to detect them as early as possible. Manually taking and describing an MRI image is time-consuming and highly dependent on the operator's experience. During a fetal brain MRI, artificial neural networks perform brain segmentation which is the first and most critical step in the quantitative analysis of the fetal brain, measuring parameters such as the diameter of the brain and biparietal bone. Difficulties to automatic fetal brain segmentation in MRI imaging can include an intensified occurrence of motion artifacts, such as spontaneous movements of the fetus or even maternal breathing. Furthermore, convolutional neural networks identifying different MRI sequences enable the visualization of smaller vascular structures and cranial nerves [36-37].

The use of AI in fetal MRI therefore represents a breakthrough in science. Motion preprocessing and correction tools make it possible to overcome the main difficulty in imaging studies, that is obtaining high-resolution images of a constantly moving object, in this case a fetus, which also reduces scanning time. Thanks to the development of this method, it is possible that each image slice within the acquisition will be evaluated and at the end of the procedure, only those with the lowest image quality scores would be reacquired by the MRI scanner, so only defective images due to high fetal mobility would have to be reacquired, instead of all of them. Placental segmentation has also been reported to be helpful in detecting such pregnancy complications as placenta accreta or fetal growth disorders. All these technologies may contribute to effective reduction of congenital disability and mortality rate by enabling the detection of various congenital defects and intervening as quickly as possible in a proper way [38].

3.6 In Vitro Fertilisation (IVF)

Couples having difficulty getting pregnant now have the opportunity to consider in vitro fertilization (IVF). The effectiveness of this method depends on a number of factors, and additionally is associated with a high risk of miscarriage [39]. New methods using artificial intelligence offer the possibility to increase the effectiveness of the transfer.

The main challenge of IVF is the process of selection of the best embryos. Morphology, time-lapse microscopic photography, and embryo biopsy with preimplantation genetic testing are used to evaluate them. Despite numerous tests, it is difficult to predict the success rate of implantation in humans [6]. Addressing this issue was the system presented by Zaninovic et al. which, by analyzing 50 392 images from 10 148 embryos, achieved an accuracy of 97.53% in identifying a good blastocyst [1,10]. Additionally, the new methods save the embryologist time during embryo selection, which speeds up the IVF process [41].

Kaufmann et al. developed a system that, by considering the age factor, the number of eggs recovered and transferred, and whether embryo freezing occurred, predicted the probability of IVF success. This system had 59% predictive power [1]. What is more, it is also possible to use artificial intelligence to determine which embryo transfer method is most beneficial depending on the age of the patient, as Van Loendersloot et al. did with their decision tree model [42].

Table 1. Impact of AI on IVF [1,3,7,10,40,43]

Category	Use of AI
Embryo Selection	embryo assessment, thanks to developed schemes and systems that use, among other things, time-lapse images of single blastocyst transfers
	recognition of specific locations in embryos such as cell mass and trophectoderm
IVF Process Optimization	optimizing embryo culture conditions and transfer times
	determining which embryo transfer method is most beneficial depending on the age of the patient
IVF Success Prediction	predicting the probability of success of IVF
	finding new factors influencing the success of IVF
Male Fertility	analysis of sperm and sperm selection
Female Fertility	predicting the likelihood of ovarian reserve, miscarriage and timing of ovulation

However, despite the many advantages of using artificial intelligence in the IVF procedure, there are also a number of problems in incorporating this method in some laboratories, especially those that still use paper charts and do not store digital images of embryos. It should also be noted that some clinics use different parameters, such as the timing of blastocyst imaging, which affects the accuracy of such systems [41].

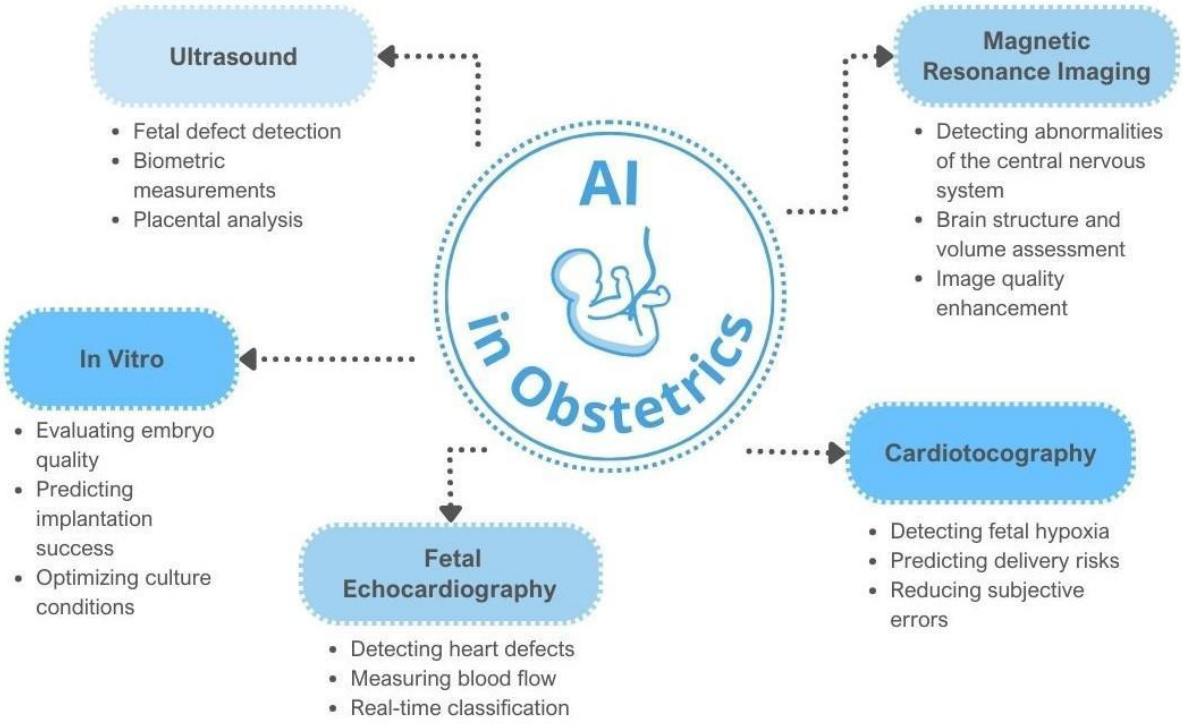

Figure 1. Applications of Artificial Intelligence in Obstetrics – Enhancing Diagnosis, Monitoring, and Predictive Care [1-3,6,10,13,19,24-27,34-38]

5. Conclusions

Artificial intelligence is becoming more and more prevalent in our daily lives. The speed of its development is rapidly increasing, and so are people's expectations of the new technology. This technology will possibly bring opportunities for better medical care in obstetrics. It will enable better diagnosis and more effective treatment.

In obstetrics, artificial intelligence has applications in many examinations used on a daily basis, such as ultrasound or cardiotocography. With advanced algorithms, it is possible to detect anomalies more accurately and quickly, which can lead to earlier intervention and implementation of treatment. In addition, AI technologies can help improve the accuracy of reading cardiotocographic signals, which carries great significance during labor. Other uses of artificial intelligence can be seen in imaging methods such as MRI. AI can be used to better analyze images, helping to detect fetal malformations and other pregnancy complications that would be difficult to detect with traditional methods.

The impact of this technology in the in vitro procedure should be noted as well, as it brings an opportunity for the development of better treatments for infertility. AI can be used to improve the outcome of in vitro procedures through, among other things, better embryo selection and optimisation of culture conditions, thereby increasing the chances of a successful pregnancy.

While artificial intelligence offers many benefits, there are also problems that come along with this technology. One of the main concerns is the issue of data security, especially sensitive medical information, which should be properly protected. Ethical concerns and assuring patients that the technology will be used responsibly remain an important issue. Therefore, it is important to conduct further research into this technology and as well as to legally regulate the use of this technology in medicine. In this way, AI can become an invaluable tool to help improve maternal and child health.

Disclosure

Author Contributions

Conceptualization, Anna Oleszczuk and Patrycja Pelczar; methodology, Patrycja Pelczar; software, Weronika Woźniak; check, Weronika Woźniak, Aleksandra Skowron and Patrycja Pelczar; formal analysis, Anna Oleszczuk; investigation, Aleksandra Skowron; resources, Weronika Woźniak; data curation, Anna Oleszczuk; writing – rough preparation, Anna Oleszczuk, Weronika Woźniak, Aleksandra Skowron and Patrycja Pelczar; writing – review and editing, Patrycja Pelczar; visualization, Anna Oleszczuk; supervision, Żaneta Kimber-Trojnar and Bożena Leszczyńska-Gorzelak; project administration, Żaneta Kimber-Trojnar and Bożena Leszczyńska-Gorzelak; All authors have read and agreed with the published version of the manuscript.

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