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Mini Review

Artificial Intelligence (AI) in Clinical and Surgical Gynecology: A Mini Review

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Abstract

The integration of artificial intelligence (AI) into clinical and surgical gynecology holds significant promise for enhancing diagnostic accuracy, individualizing treatment plans, and improving patient outcomes. This review discusses the current applications and potential of AI in gynecology, including virtual and physical AI. Virtual AI is utilized for pattern recognition in diagnosis, treatment planning, and outcome prediction, particularly in gynecological malignancies, assisted reproductive techniques, and urogynecology. Physical AI, especially in gynecological surgery, incorporates augmented reality through computer-aided or robotic platforms. Despite its advancements, AI is not yet fully integrated into modern medical practice. This review emphasizes the need for further research and larger datasets to maximize AI's potential in gynecology.

Keywords: Artificial intelligence; Robotic surgery; Gynecology

Introduction

Artificial intelligence (AI) technology is revolutionizing various medical fields, including gynecology, by enhancing risk assessment, disease diagnosis, treatment success prediction, patient monitoring, and management of treatment complications [1]. AI software analyzes large datasets using complex algorithms, which assists clinicians in making more confident decisions without replacing their expertise [2]. The application of AI in gynecology can be categorized into virtual AI and physical AI, each serving distinct purposes and offering unique benefits.

Virtual AI in Clinical Gynecology

Virtual AI aids in the diagnosis, treatment planning, and outcome prediction of gynecological malignancies, assisted reproductive techniques (ART), and urogynecology [3]. In ART, AI applications involve creating reproductive health databases from electronic medical records, which are then analyzed using machine learning algorithms to select high-quality sperm, oocytes, and embryos [4]. This process improves efficiency, reduces errors, and decreases the workload for clinicians [5].

AI in Assisted Reproductive Technology

AI technology plays a crucial role in the selection of high-quality sperm, oocytes, and embryos in ART. The workflow begins with data collection from electronic medical records, hospital data, and cloud data sharing, which includes patient characteristics, treatment history, and clinical laboratory findings [6]. This data

is then analyzed using AI methods such as machine learning and natural language processing to create predictive models [7]. These models help in training, evaluating, and validating AI systems, ultimately improving the success rates in reproductive medicine [8]. For instance, AI applications using integrated image analysis have been developed to automatically classify oocytes, sperm, and embryos, aiming to increase efficiency and reduce errors [9].

AI has also been instrumental in predicting outcomes in ART. A study using neural networks identified developmentally competent mouse oocytes with an accuracy of 91.03% [10]. This protocol could potentially be applied to human oocytes, enhancing the success rates of ART procedures [11]. Furthermore, AI-driven systems such as computer-assisted sperm analysis (CASA) help in assessing sperm motility and morphology, which are critical factors in reproductive health [12].

AI in Gyneco-oncology

In gyneco-oncology, AI assists in personalizing treatment plans based on individual patient data, including genetic makeup and medical history [13]. AI models can predict cancer progression by analyzing genetic mutations such as KRAS in endometrial cancer [14]. Additionally, AI applications in radiology help distinguish malignant uterine sarcomas from benign leiomyomas using MRI criteria, potentially changing treatment approaches for atypical uterine masses [15].

AI technology also supports clinical decision-making in gynecological malignancies. For instance, an AI model using data from 668 epithelial ovarian cancer cases was developed to predict overall survival and surgical outcomes [16]. Similarly, AI algorithms analyzing colposcopic findings and HPV biomarkers have shown high sensitivity and specificity in predicting cervical intraepithelial neoplasia [17]. These advancements highlight AI's potential in enhancing diagnostic accuracy and treatment personalization in gyneco-oncology.

Physical AI in Gynecological Surgery

Physical AI, often through robotic platforms, enhances preoperative and intraoperative imaging, thereby improving surgical outcomes [18]. Robotic surgery is particularly beneficial in treating complex gynecological diseases such as endometriosis and uterine leiomyomas by offering precise surgical interventions with reduced risks and shorter recovery times [19]. For example, robotic myomectomy has shown advantages over traditional methods, including reduced blood loss, smaller scars, and fewer postoperative complications [20].

Robotic surgery combines AI with minimally invasive techniques, improving surgical precision and patient outcomes [21]. AI-based endoscopy systems can estimate the depth and location of critical structures like the ureters during surgery, increasing safety and reducing risks [22]. Additionally, AI applications in 3D imaging provide detailed visualizations of surgical fields, aiding in surgical planning and execution [23].

Advancements in Robotic Surgery

Robotic-assisted surgery has demonstrated superiority in managing various gynecological conditions, including uterine leiomyomas, adenomyosis, and endometriosis [24]. For instance, robotic myomectomy offers benefits such as reduced blood loss, shorter hospital stays, and fewer complications compared to abdominal and laparoscopic myomectomy [25]. Studies have also shown better reproductive outcomes with robotic surgery for deeply infiltrating endometriosis [26]. Furthermore, new minimally invasive approaches like laparoendoscopic single-site (LESS) surgery and natural-orifice transluminal endoscopic surgery (NOTES) are being developed to further reduce surgical trauma and improve outcomes [27].

Conclusion

AI offers promising advancements in clinical and surgical gynecology by providing personalized diagnostic and treatment algorithms and improving surgical outcomes through enhanced imaging and robotic assistance. Despite these benefits, AI is not intended to replace clinicians but to support their decision-making processes. Continued research and data expansion are essential for fully integrating AI into modern medical practice.

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Conflict of Interest

Author declare no conflict of interest.

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