Elbiss and Abu-Zidan *International Journal of Emergency Medicine* (2025) 18:20
https://doi.org/10.1186/s12245-025-00820-8

International Journal of Emergency Medicine

REVIEW

Open Access

Artificial intelligence in gynecologic and obstetric emergencies

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Abstract

Background Artificial intelligence (AI) uses a process by which machines perform human-like functions such as automated clinical decisions. This may operate efficiently in gynecologic and obstetric emergencies. We aimed to review the role and applications of AI in gynecologic and obstetric emergencies.

Methods A literature search was carried out in November 2023 in PubMed, Cochrane Library and Google Scholar using the keywords combination of "artificial intelligence, gynecology and obstetrics". Relevant articles were selected and read. Reference lists of the selected articles were also searched.

Results The literature demonstrated the role of AI to improve healthcare in emergency settings in several aspects such as diagnostic imaging, improving predictions in emergencies, and improving planning and resource allocation for emergency services. AI works objectively, overcoming human biases in decision-making. Creating interconnected data registries for AI will likely enhance its performance. Validation research in emergency settings has shown that AI-prediction tools perform more accurately compared with the estimation of risk and outcomes by gynecologists and obstetricians in emergency situations including endometriosis and acute abdominal pain. There was acceptance of AI and its potential benefits. Ethical dilemmas of using AI include data governance, responsibility for errors, and security issues. Providing training on AI to healthcare professionals working in emergency departments is needed.

Conclusions Healthcare professionals should educate themselves about the anticipated role of AI in gynecologic and obstetric emergencies, its indications, limitations, and ethical considerations so that they can take steps towards its application in their future practice using defined guidelines.

Key message

Why is this review is important? The use of AI in healthcare has created polarized thoughts among emergency medicine professionals. This review is an effort to compare the pros and cons of using AI in gynecologic and obstetric emergencies so that AI can be properly applied in these specialities.

What does this review show? This review shows that there are several research studies in gynecology and obstetrics emergencies with positive points in favor of using AI in emergencies like acute abdominal and pelvic pain, and endometriosis. There are some reservations from the practitioners to use it due to lack of understanding of its nature, advantages and limitations. By narrating the findings of AI-related publications in gynecology and obstetrics emergency, we propose their applications and their limitations.

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What are the key findings? AI can help in critical decision-making in emergency gynecologic and obstetric situations under the conditions of correct input information and human supervision. So, AI can assist gynecologists in deciding which treatment approach to use in emergencies and it may also reduce the burden on human professionals and save time by prompt interventional decisions.

How is patient care impacted? Using AI with the input of trained medical professionals and software engineers, decision-making in gynecologic and obstetric emergencies can be made more efficient. AI-assisted tools can predict the outcomes of patients rapidly, saving time and avoiding delays in directing further care.

Keywords Artificial intelligence, Gynecology, Obstetrics, Emergency

Introduction

There have been major developments of data collection, storage, and analysis over the last five decades including health informatics. Computers have developed from being large with slow processors and very limited data storage to be small, fast in processing, with large data storage. Supercomputers have great capabilities and can spend days analysing data to develop simulations or predicting models that are difficult to process by ordinary human brains. The "Knowledge Pyramid" model explains the progress of collecting data which is analysed to get information that will increase our knowledge and finally our wisdom [1] (Fig. 1). These developments led to the thrive of "artificial intelligence" which tries to mimick the human mind. There has been major recent interest in AI in the medical literature. Searching the term "artificial intelligence" in PubMed database during the period of 1951 to 2023 shows a dramatic exponential growth in this interest. While there was less than 10 annual articles in the database before 1971, they jumped to more than 37,000 articles during 2023 (Fig. 2).

The AI is defined as the ability to reason and learn like humans. Machine learning is developing algorithms that can learn without being programmed. This helps machines to perform human-like cognitive functions and decision making without requiring the user to input extensive programming commands [2]. It aids via automated clinical decisions using large medical databases, which can operate efficiently and accurately in emergency situations [3–5]. An accepted degree of accuracy was obtained when AI was used to triage patients with acute abdominal pain, including menorrhagia. This may use multiple input variables to have a quick decision [6]. The use of contemporary AI-related technology in healthcare is being driven by a number of factors, including human error in emergency situations and workload. For example, AI can help to decrease fetal monitoring errors during intrapartum obstetrics [7], and to shorten the time it takes to diagnose malignancies in gynecological oncology [8].

As the world becomes more interconnected, health care can benefit from AI by using high-quality data collected in international registries to develop decision-making automated tools. However, the potential for errors requires that healthcare providers in emergency settings fully understand the limitations of AI [9]. Surgical specialities, including gynecology and obstetrics, ought to be fully knowledgeable about the appropriate application of AI because avoidance of unnecessary operative procedures is a key goal of emergency care [10]. AI is being used for various purposes like diagnostic imaging, improving prediction from a public health emergency perspective, identifying patterns of injury from massive medical datasets, and improving the planning and resource allocation for emergency services [3, 11, 12]. AI was useful in avoiding unwanted surgeries by resolving diagnostic challenges in patients with pelvic pain when sonography and MRI were inconclusive [12]. The application of AI is currently variable and there is a need to present a targeted evidence synthesis about its potential to gynecologists and obstetricians providing emergency healthcare. Therefore, we aimed to review the role and applications of AI in gynecologic and obstetric emergencies.

Methods

This review was carried out in compliance with the guidelines for writing narrative reviews [13]. We searched the following medical databases: PubMed, Google Scholar, and Cochrane library on November 2023 for articles published in English without time restriction. The keywords combination captured the concept of "artificial intelligence, gynecology and obstetrics" using medical subject headings, text words and word variants appropriately with boolean operators. Search term combination for gynecology and obstetrics was extended to cover "endometriosis, acute pelvic pain or acute abdominal pain; ectopic pregnancy, miscarriage, obstetric hemorrhage and intrapartum care". Titles were browsed, abstracts of interest were read, and relevant articles were selected based on personal judgement on its relevance to this review. The articles were retreived through the National Medical Library of the United Arab Emirates University [14]. The retreived articles were then critically read and summarized. Illustrations were selected from open access

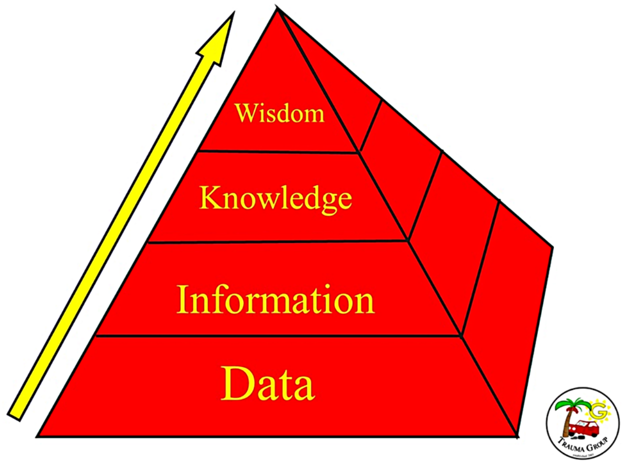

Fig. 1 The DIKW pyramid consists of four components: data, information, knowledge, and wisdom, that develop overtime from base to top (Illustrated by Professor Fikri Abu-Zidan, The Research Office, College of Medicine and Health Sciences, United Arab Emirates University)

sources or when deemed necessary were drawn by the authors.

Definition of AI and related terminology

AI is the branch of computer science which incorporates algorithms to perform tasks that usually require human intelligence (language understanding, information retrieval, reasoning, and learning) which they were not programmed to perform. An *algorithm* is an ordered number of finite computational steps to solve a problem. *Machine learning* (ML) is a mixture of various AI techniques, both supervised and unsupervised, that allow algorithms to *learn* from complex provided information and past experiences to perform tasks carried out by humans, iteratively improving with time without the need for incorporating further programming commands. Algorithms use the *input data* to develop statistical models. This process is called *training*. Each variable in the input data is called a *dimention.* [15]

Deep learning, involves algorithms that use different processing layers to provide high level information from simple inputs [16]. *Artificial neural networks* (ANN) are a category of deep learning. They are advanced models that mimick human neuron network. They are more complex models which explore non-linear relationships between the input data and the output oucome of interest. They have at least three layers: (1) input layer, (2) hidden layer, and (3) output layer (Fig. 3). There may be more than one hidden layer. Each neuron of a layer is connected with every neuron of the following layer but not with the neurons of the same layer [15]. The progress of of an output of a neuron is controlled by an equation that works as a gate permitting the progress of the output. This is called *the activation function or transfer function*. The activation function will decide the activation of the neuron [17, 18]. The input to a neuron is weighted by different variables of a model allowing for the learning process to develop between the input and output layers [15]. To achieve an accurate output, the weights and biases should be

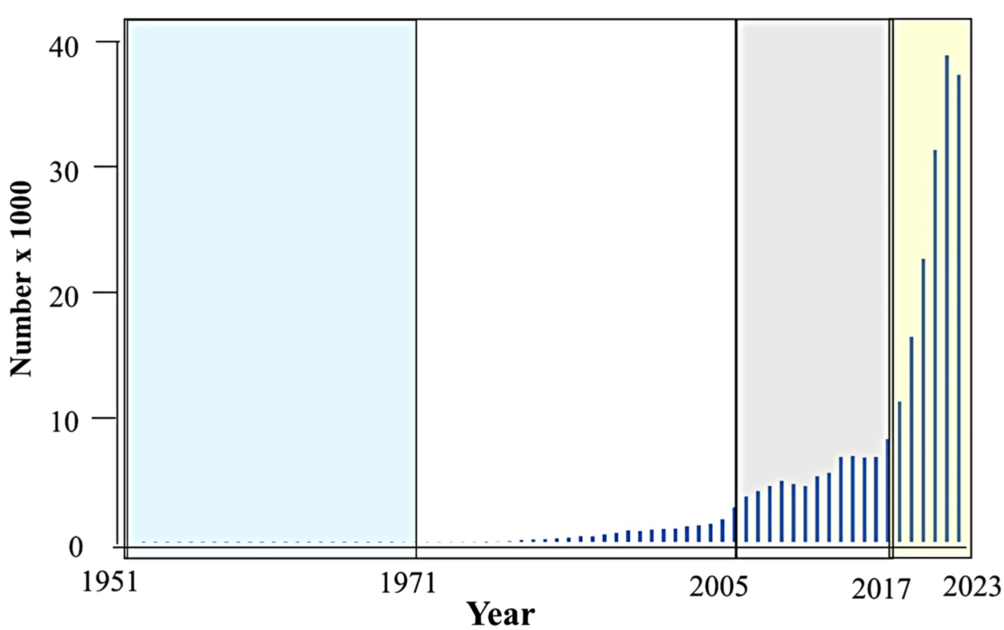

Fig. 2 PubMed Search result of the term "artificial intelligence" for the period of 1951 to 2023 shows its dramatic exponential growth. There was less than 10 annual articles before 1971 while it reached more than 37 000 articles in year 2023 (Illustrated by Professor Fikri Abu-Zidan, The Research Office, College of Medicine and Health Sciences, United Arab Emirates University)

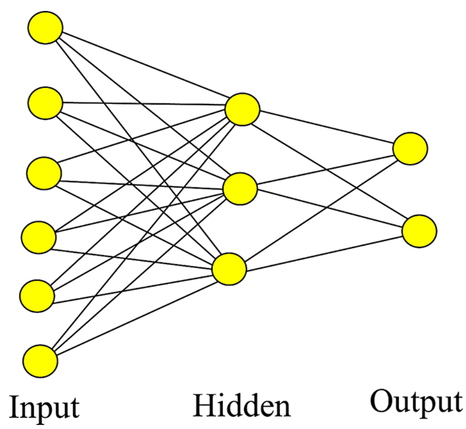

Fig. 3 Artificial neural networks, which mimick human neuron networks, have at least three layers: (1) input layer, (2) hidden layer, and (3) output layer. Each neuron of a layer is connected with every neuron of the following layer but not with the neurons of the same layer (Illustrated by Professor Fikri Abu-Zidan, The Research Office, College of Medicine and Health Sciences, United Arab Emirates University)

updated to the neurons depending on the feedback of the error in the output. This is called *back propagation* [18].

Computer Vision algorithms try to break down images by studying their different parts. Based on repeated observations learnt from different images, the machine classifies these findings to make an output decision like diagnosis [19]. *Data mining* (DM), is the discovery of relationships, patterns and anomalies in data within large datasets to generate future predictions which are generally invisible to humans. Text mining deploys text as data. *Natural language processing* (NLP), a further AI technique, enables computers to read, understand and interpret a human's natural language using computational linguistics. *Information retrieval* (IR) organizes, stores, and retrieves textual information from a database or document collections. A search engine is an information retreival (IR) system, where the user formulates a query and a retrieval model captures documents ranked according to their relevance. IR can then deploy techniques from ML and NLP to improve query formulation and document selection.

Uses of AI in gynecological and obstetric emergencies

Emergency gynecologic presentation may include pelvic masses and ovarian cysts (with or without ovarian cancer), acute abdominal and pelvic pain, ectopic pregnancy, endometriosis, miscarriage and abortion, acute presentation of gynecological cancer, breast lumps and discharge, pelvic prolapse related emergencies, heavy menstrual bleeding, and infertility treatment emergencies (acute abdominal pain due to ovarian hyperstimulation) [11, 20]. Currently, AI is helping gynecologists in emergencies from diagnosis to treatment, with added human supervision [8]. As a specific example, AI is being used by aiding radiological diagnosis for detecting breast cancers [8]. It is also being developed for use in the diagnosis of women with endometriosis [11], and triage of acute abdominal pain [6]. Jiang et al. compared the diagnostic accuracy of MRI in 116 patinets having ovarian endometriosis using three methods; conventional MRI, and two AI algorithms: 1) the traditional hard C-means (HCM) algorithm, and b) the fuzzy C-means (FCM) clustering algorithm. The diagnostic accuracy was highest in the FCM followed the HCM and then conventional MRI (94.3%, 81.4%, and 63.2 respectively). Image quality evaluation was significantly higher in the FCM compared with the HCM algorithm (Dice, sensitivity, and specificity of 0.92, 0.9, 0.93 for FCM compared with 0.77, 0.73, and 0.72 for HCM [11]. Robotic surgery is another example where the use of AI is useful [21]. AI simplifies molecular biology gynecologic cancers [10]. Using AI-powered MRI algorithms, hysterectomy procedures can be performed more effectively, with reduced bleeding and shorter operative times [22]. The study demonstrated a statistically significant decrease in intraoperative blood loss [10.00 (6.25-15.00) ml vs. 10.00 (5.00–15.00) ml, $p = 0.04$] and surgical duration (41.32 ± 17.83 min vs. 32.11 ± 11.86 min, $p = 0.03$) in operations aided by AI [22]. Despite reporting statisitcal significance for bleeding, we think that this was not clincially significant. The authors used non parametric methods for comparing the blood loss (Mann Whitney -U-test) which compares the ranks and not crude data, so statisitcal significance can be present despite having the same median of 10 ml.

Handling obstetric emergencies is crucial. Poor decision-making and inappropriate interventional options lead to high death rates and several comorbidities. For example, every year, prenatal problems claim the lives of around 3.5 million babies [23]. The idea behind the use of new technologies, like AI, in healthcare is to simplify difficult decision-making, support medical personnel in making the best decisions, and enable them to handle emergency cases in a timely manner. In obstetric emergencies, ML algorithms can yield a variety of benefits. ML algorithms have been successfully utilized to diagnose pathologies by monitoring fetus movements with fewer false positive values [7]. According to another study, ML algorithms were used to detect the need for cesarean and vaginal deliveries. The results demonstrated 94% sensitivity, 91% specificity, and 99% area under the curve attained by ML classification. This meant that, compared to obstetrician and midwife predictions and methods reported in earlier studies, ML greatly enhanced the efficiency for the detection of caesarean section and normal vaginal deliveries using foetal heart rate data [24].

DM algorithms can be used for screening women with abnormal uterine bleeding and predicting endometrial cancers [25]. Scores which were developed by AI successfully predicted the risks for different postoperative complications in general surgery. The study used *MySurgeryRisk* output scores to predict eight outcomes (acute kidney injury, ICU admission greater than 48 h, mechanical ventilation greater than 48 h, wound complications, neurological problems, cardiovascular problems, sepsis and venous thromboembolics) [26]. By using accessible preoperative electronic health records data, the automated predictive analytics framework (*MySurgeryRisk* output score) for a ML algorithm had high discriminatory capacity for estimating the likelihood of surgical complications and death [26]. These findings confirm that AI has a role in emergency medicine and suport performing more research in gynecologic and obstetric emergencies so as to precisely define the role of AI in this important area. A recent study on women having ovarian endometriosis showed that an AI algorithm using the MRI images significantly improved the diagnostic accuracy [11]. In another example, the application of AI in the triage of women with acute abdominal pain produced accurate models for rapid assessment and triage [6]. The study included 215 patients presenting with different levels of severity of acute abdominal pain who were assessed by an emergency physician for triage compared with AI. All systems demonstrated a decent degree of prediction at triage level 2, with neural networks demonstrating the highest level and accepted degree of prediction in triage Level 3. Nevertheless, the decision tree was the only method with an acceptable prediction at triage level 4 [6].

Practitioner perspective

An international survey regarding the use of AI in emergency healthcare revealed that the majority of surgeons acknowledged the benefit of AI in emergency surgical practice with respect to improving pre- and post-operative decision-making [12]. Though surgeons were enthusiastic about AI in this survey, almost a third were not familiar with AI terms, definitions and applications [12]. Those unfamiliar with AI had contrary opinions, indicating the need for education and training. In gynecology, the perspectives are likely to be similar. Continuing medical education has an important role for the road to implement AI in obstetrics and gynecologic emergencies. In order to overcome anticipated obstacles, interdisciplinary collaborations should be built between healthcare practitioners and AI developers. This requires training of practitioners on digital health [9, 27].

Ethical considerations

Autonomy, beneficence (non-maleficence) and justice are the key medical ethics principles. These issues surface in the introduction of AI in emergency surgery. Informed decision-making is key to the ethical implementation of AI. There are several questions raised about data governance and security, responsibility for errors, and technical efficiency in emergency settings [9]. The adoption of AI is linked to the requirement for large training datasets and algorithm validation. It is important to carefully handle technical as well as ethical issues that inevitably impinge on patient consent and data protection. AI cannot just be forced through as a black box. Gaining the trust of patients and healthcare professionals requires ensuring that AI algorithms are transparent and comprehensible.

General considerations

AI is in the limelight in almost every field. It is evolving its applications in healthcare, but some tools at this stage are not fully automated. The literature shows that AI is being incorporated in medicine generally. Emergency setting is no exception. The role of AI for gynecologic and obstetric emergencies is developing. Early diagnosis of emergency problems is made possible by real-time predictive analytics using AI which has the potential to improve patient outcomes. In terms of cognitive capacity, the human brain can process far less than the basic computers, which can perform calculations that are millions of times more complicated than human neural bandwidth [28]. There is a wide range of opinions about the use of AI in emergency settings [12]. We have to acknowledge that there may be an exagerated hope at this stage. The Gartner Hype Cycle demonstartes the natural development of a new technology (Fig. 4). We are at the initial enthusiasm phase as demonstrated by Fig. 2. We anticipate that this will be followed by the adoption and evaluation phases in which lessons learned from encountered mistakes will refine the technique of AI and and its useful use. We hope finally to reach the maturity phase in which the role and indications of AI are well estabished and proven.

Applying AI in emergency medicine has the advantage to use superior computational power of computers to rapidly extract information from big data of observations which can be accurate in predicting clinical outcomes. Compared with gynecologists working in emergency healthcare who tend to have linear thinking, AI can identify intricate linear as well as nonlinear interactions of risk factors using the ANN models [29]. Armed with this ability AI can provide an extremely precise estimation of the risk of morbidity and mortality by utilizing ML methods quickly when it matters in an emergency [29]. AI predictor tools can guide practitioners to follow specific steps as they can foresee the outcomes of the decisions or steps they are planning to take for a patient in an emergency [29]. In this study involving 934,053 patients, the Trauma Outcome Predictor (TOP), an interactive smartphone application, was used to predict the outcomes. Mortality was reliably predicted by the TOP (Area Under

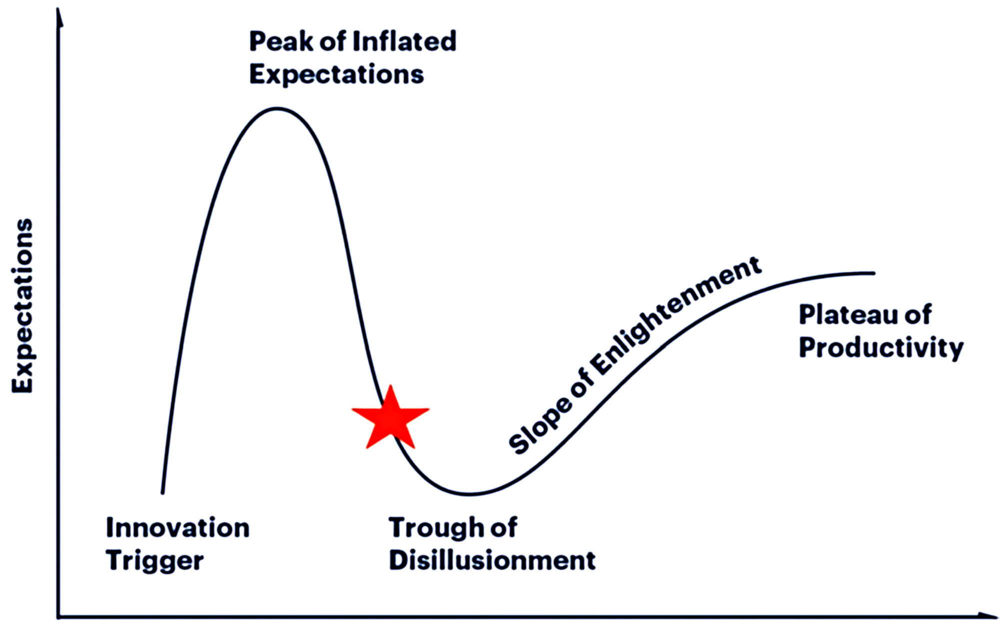

Fig. 4 The Gartner Hype Cycle methodology describes how the perceived value of a given technology evolves. Reproduced from De Simone B et al. Knowledge, attitude, and practice of artificial intelligence in emergency and trauma surgery, the ARIES project: an international web-based survey. World J Emerg Surg. 2022;17:10 which is distributed under the terms of the Creative Commons Attribution 4.0 International License

the Curve (AUC): 0.95 in derivation and 0.94 in validation in penetrating injuries and 0.89 in derivation and 0.88 in validation in blunt injuries). The range of the validation AUC for predicting complications was lower (0.69 to 0.84) [29]. This is expected, as prediciton of complications (multiple categorical data) is more difficult than prediciting a solid binomial outcome variable like death. Furthermore, AI can do this task objectively, overcoming human biases that are at play consciously or subconsciously in taking particular decisions. For example, both patients and clinicians may have biases towards cesarean Sect. [30]. However AI-tools will make predictions in a non-biased fashion as they follow principles from the numeric information provided [26]. It has even shown potential for objective evaluation in clinical examination through the use of NLP in gynecology [31].

Care in emergency wards is always critical to provide as there is very little time to take bold and risky decisions. Trauma management is a similar situation of high risk critical decision making in which quick decisions has to be made once, in a very short time and cannot be reversed. The workload in emergency departments is always high and almost 50% of the cases are of trauma nature [32]. AI can assist in managing these issues with the help of data input by reducing the load in emergency care by making the right diagnosis, treatment options and transferring patients to the relevant wards within no time if, the correct input information are provided to generate AI algorithms to take such human-like decisions [31]. AI made accurate prediciton of death in the elderly trauma patients [33]. Similarly, another study showed accurate prediction for the need of ICU admissions after trauma emergency surgery using AI-based tools [34]. Furhtermore, AI achieved accurate prediction of risks and outcomes in patients with penetrating and blunt trauma [33]. AI was also used in the radiological diagnosis of fractures [16]. It is anticipated that similar advantages can be transferred to emergency obstertics and Gynecology especially in managing trauma in pregnancy which involves both the mother and fetus. AI application in emergency and gynecological settings have resulted in potential advantages which created more future opportunities [35]. Emergency surgery and gynecology require accurate and timely diagnosis, triage and treatment. AI tools, such as NLP and machine learning algorithms, have demonstrated the potential to support surgical diagnosis in life-threatening circumstances. Research has revealed how effective AI can be in anticipating surgical difficulties and enabling prompt interventions [36]. Another area where AI is essential is in the use of robotics in emergency surgery and gynecology. AI-powered surgical robots give doctors more precision and agility in anatomical work. Research emphasizes the effective use of robotic assistance in emergency surgery, with a focus on lower morbidity and faster recovery times [21].

Future applications of AI in gynecologic and obstetric emergencies appear promising. AI systems will be much more powerful with continued research and development in computer sciences. Integrating AI technologies could transform the surgical scene by giving doctors access to real-time, context-aware information during surgeries. To ensure the safe and ethical integration of AI in surgeries, defined norms must be established. Medical practitioners, AI developers, and regulatory organizations must collaborate to achieve this target. Emergency healthcare practitioners will need to engage in ongoing multidisciplinary education and training programs.

Limitations of AI

Although there have been encouraging developments in the use of AI in gynecologic and obstetrics emergency, the difficulties in integrating AI into established gynecologic and obstetrics emergency procedures should not be underestimated. It is important to highlight that AI cannot completely replace health professionals. The main limitation of AI clinical decision making is that its performance is not perfect in accuracy and prediction. Nevertheless, it may enable health professionals to make rapid diagnosis permitting them to spend more time discussing medical management with patients or their relatives. Thus, it could contribute to reducing the burden of work and burnout but not completely replacing the physician. Furthermore, critical clinical decision making is a complex process, and should take the disease, the patient's condition and preference, and the setting of the patient to be proper. It should be individualized by taking a shared informed decision. AI can be helpful in evaluating the risks while the patient or legal representative and the treating physician can take their shared decision. Besides, AI has multiple limitations that have to be taken into consideration. *First*, the accuracy of any statisitical modelling for an algorithm depends on the accuracy of the data entered. Incorrect or missing data can affect the accuracy of the predicitng model. *Second*, the usefullnes of a predicitng AI model depends on the population it was derived from and may not be generalized worldwide. *Third*, most of clinical studies, advances in information literacy, and data collection comes from developed countries which limits its usefullnes in developing countries. *Fourth*, researchers can be biased towards restricting important variables by their own previous bias. Finally, socioeconomic, gender-based, racial, and linguistic bias can affect the accuracy of AI models [37, 38].

Conclusions

The use of AI in gynecologic and obstetric emergencies is promising. When appropriate input data are provided, and human expert oversight is available, AI can assist in critical decision making and predict outcome in emergency situations. This can save time and prevent delays in management. Because gynecologists and obstetricians are unfamiliar with AI principles and terminology, they may be skeptical about its value.

Abbreviations

AI	Artificial Intelligence
ANN	Artificial neural networks
ML	Machine learning
DM	Data mining
IR	Information retrieval
NLP	Natural language processing
ICU	Intensive care unit

Author contributions

Conceptualisation (H.M), data curation (H.M), formal analysis (F.A), funding acquisition (N/A), investigation (H.M), methodology (H.M), project administration (H.M, F.A), resources (N/A), software (N/A), supervision (F.A), validation (N/A), visualisation (F.A), writing – original draft (H.M), and writing – review & editing (F.A).

Funding

Not applicable.

Data availability

No datasets were generated or analysed during the current study.

Declarations

Ethical approval

Not applicable.

Consent to participate

Not applicable.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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Received: 25 February 2024 / Accepted: 30 January 2025
Published online: 10 February 2025

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