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Artificial intelligence in action: Improving breast disease management through surgical robotics and remote monitoring

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ABSTRACT

Objectives: This article aims to discuss the transformative impact of artificial intelligence (AI) on the identification and management of breast diseases, with a specific focus on breast cancer.
Materials and methods: Healthcare providers have integrated AI technologies such as surgical robots and remote monitoring systems to improve the accuracy and efficiency of breast disease diagnosis and treatment.
Results: Surgical robots equipped with AI algorithms provide real-time guidance to surgeons, analyze imaging data, and ensure precise procedures for better outcomes in breast cancer surgeries. AI-driven remote monitoring systems allow for close monitoring of patient health data, disease progression prediction, and personalized treatment recommendations.
Conclusions: The incorporation of AI technology into healthcare practices for breast diseases has revolutionized patient care delivery, enhancing outcomes, promoting patient engagement, and improving overall quality of care. These advancements offer personalized and tailored healthcare strategies that meet the unique needs of each patient, reshaping the healthcare industry.

Inteligencia artificial en Acción: Mejorando el Manejo de Enfermedades de mama a través de la Robótica Quirúrgica y el Monitoreo Remoto

Palabras clave:
Inteligencia Artificial
Enfermedades de Mama
Cáncer de Mama
Robots Quirúrgicos
Sistemas de Monitoreo Remoto
Tecnología de la Salud

RESUMEN

Objetivos: Este artículo tiene como objetivo discutir el impacto transformador de la inteligencia artificial en la identificación y manejo de enfermedades de mama, co con un enfoque específico en el cáncer de mama.
Materiales y Métodos: Los proveedores de atención médica han integrado tecnologías de IA como robots quirúrgicos y sistemas de monitoreo remoto para mejorar la precisión y eficiencia del diagnóstico y tratamiento de enfermedades de mama.
Resultados: Los robots quirúrgicos equipados con algoritmos de IA brindan orientación en tiempo real a los cirujanos, analizan datos de imágenes y aseguran procedimientos precisos para obtener mejores resultados en cirugías de cáncer de mama. Los sistemas de monitoreo remoto impulsados por IA permiten un seguimiento cercano de los datos de salud del paciente, predicciones sobre la progresión de la enfermedad y recomendaciones de tratamiento personalizado.
Conclusiones: La incorporación de la tecnología de IA en las prácticas de atención médica para enfermedades de mama ha revolucionado la prestación de cuidados a los pacientes, mejorando los resultados, fomentando la participación del paciente y mejorando la calidad general de la atención. Estos avances ofrecen estrategias de atención médica personalizadas que satisfacen las necesidades únicas de cada paciente, reconfigurando la industria de la salud.

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Introduction

The realm of medicine is being revolutionized by artificial intelligence (AI), presenting new opportunities for the diagnosis and treatment of various illnesses. One particular area where AI is showing promise is in the identification and examination of breast diseases, particularly breast cancer, which is a common form of cancer in women.[1–4] Early detection is vital for successful treatment, and AI technologies like machine learning algorithms are now enabling medical experts to analyze mammograms and other medical images with greater accuracy and efficiency to pinpoint and characterize breast abnormalities. AI algorithms are trained on extensive sets of medical images to detect patterns that could indicate the presence of breast cancer.[5,6] These algorithms can identify subtle changes in breast tissue that might not be noticeable to the naked eye, thereby enhancing diagnostic precision. Furthermore, AI can also help prioritize cases based on the likelihood of malignancy, enabling radiologists to concentrate on the most concerning cases first. Additionally, AI can assist medical professionals in creating personalized treatment plans for patients with breast cancer by analyzing their medical records, imaging data, and genetic information.[7,8] This tailored approach to treatment can result in improved patient outcomes and reduced risk of unnecessary treatments or side effects. Aside from aiding in diagnosis and treatment, AI is also contributing to breast cancer research and drug development. By examining extensive datasets of genetic and clinical data, AI can aid researchers in identifying new drug targets and developing more effective treatment options for breast cancer patients, potentially expediting the drug discovery process and bringing novel therapies to the market more swiftly. Mainly, the integration of AI technologies in breast cancer diagnosis and treatment is transforming the approach to combating this disease. By delivering more precise and individualized care, AI is enhancing patient outcomes and alleviating the strain on healthcare systems. While challenges like ensuring data privacy and addressing algorithm biases persist, the benefits of AI in breast cancer care are undeniable. As AI continues to advance, we can look forward to even greater progress in improving the quality of life for individuals affected by breast cancer through more effective and precise care.

In this article, we will explore how AI is impacting the identification and diagnosis of breast conditions, along with the current advancements being made in this field. The article will focus on 2 main uses of AI in breast disease: surgical robotics and remote monitoring tools, which are shown in the Fig. 1, for early detection. By enhancing the accuracy and efficiency of detecting breast diseases, AI is transforming the healthcare sector and enhancing patient outcomes. Utilizing AI in surgical robots allows for more precise and minimally invasive procedures, while remote monitoring tools enable healthcare professionals to monitor changes in breast health over time. These technological advancements are creating new possibilities for improving the detection and treatment of breast conditions, ultimately enhancing the quality of care provided to patients.

Materials and methods

The required teaching system

To begin, we will outline the necessary educational frameworks aimed at enhancing breast health through the utilization of surgical robotics and monitoring technologies. To effectively launch a training program centered on AI applications in surgical robotics and remote monitoring for breast health, a systematic plan is essential. Initially, a comprehensive curriculum must be created, encompassing a range of crucial subjects. This curriculum should include the basics of AI and machine learning, an introduction to surgical robotics, an exploration of remote monitoring technologies, such as wearable gadgets and telehealth, as well as a review of their practical uses in breast surgery, specifically robotic-assisted operations. Moreover, it is vital to discuss data protection and ethical issues, while also offering practical experience through robotics simulations and remote monitoring tools. Subsequently, the program should aim at a varied audience. This group can comprise healthcare professionals, such as breast surgeons and surgical nursing staff, as well as radiologists and oncologists. Additionally, healthcare technology experts, including biomedical engineers and IT specialists in the medical field, should also be part of the audience. Furthermore, medical students, residents, patients, and advocates who want to make educated choices about these technologies should also be considered. When it comes to educators, the program could benefit from a blend of academic instructors—such as university professors specializing in surgery and healthcare technology—and industry professionals with real-world experience in surgical robotics and telemedicine. Input from technology creators and clinical trainers who incorporate these innovations into their work will also be crucial. The teaching techniques may vary widely and include lectures and seminars for

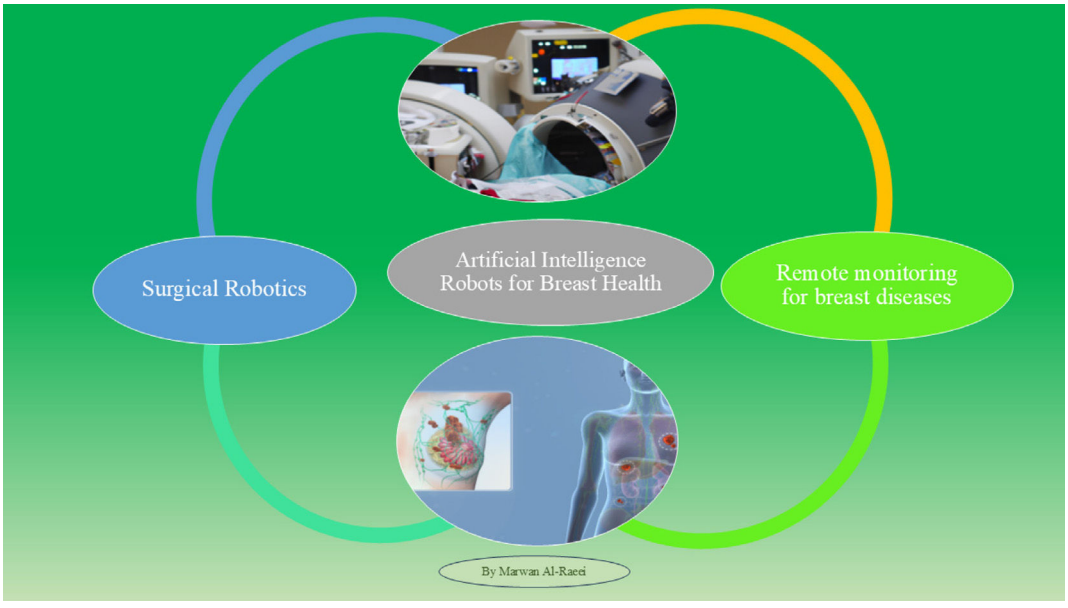

Fig. 1. Artificial intelligence robots for breast diseases.

theoretical knowledge, hands-on workshops providing practical training with surgical simulators and remote monitoring tools, in addition to online courses and webinars that offer flexible learning opportunities. Incorporating case studies and real-life clinical examples will aid participants in grasping the application and impact of these technologies in breast health.

Finally, assessing the program's success through evaluations, such as tests and hands-on assessments, is critical to gauge participants' understanding and skills. Additionally, establishing feedback mechanisms for participants will help to continuously enhance and refine the curriculum. By creating a robust educational structure that incorporates various teaching methodologies and addresses the diverse needs of the audience, healthcare professionals will be better prepared to implement AI-related technologies in surgical robotics and remote monitoring within clinical environments for breast health.

Surgical robotics for breast

Surgical robotics have completely transformed the landscape of minimally invasive surgeries for breast diseases, especially breast cancer. These advanced robots are equipped with state-of-the-art AI algorithms that significantly amplify the precision and accuracy of surgical procedures, while simultaneously decreasing the likelihood of complications.[9,10] By furnishing real-time guidance to surgeons, scrutinizing imaging data, and ensuring absolute precision, surgical robots have seamlessly ingrained themselves into the realm of operating rooms, emerging as essential instruments for triumphant outcomes in breast cancer surgeries. The utilization of surgical robots in breast cancer surgeries has steadily risen in recent years, as their functionalities and capabilities continue to progress and enhance. These robots are specifically devised to collaborate with highly adept surgeons, harnessing their proficiency and knowledge to elevate the overall quality of care extended to patients. Through the aid of sophisticated AI algorithms, surgical robots are able to execute intricate maneuvers with unprecedented levels of accuracy, ensuring that the surgical results are maximally successful. A paramount advantage of incorporating surgical robots in breast cancer surgeries lies in their ability to furnish real-time guidance to surgeons. By employing advanced sensors and imaging technology, these robots are adept at analyzing the patient's anatomy and delivering the surgeon with detailed feedback regarding the optimal course of action to pursue during the procedure.[11,12] This real-time guidance guarantees that the surgeon can traverse through intricate anatomical structures with precision and ease, subsequently leading to enhanced outcomes for the patient. Moreover, surgical robots play an essential role in scrutinizing imaging data during breast cancer surgeries. By processing imaging data instantaneously, these robots can swiftly pinpoint any anomalies or inconsistencies present in the patient's anatomy. This crucial information is then relayed to the surgeon, empowering them to make informed decisions concerning the most suitable approach to undertake during the procedure. By harnessing the potency of AI algorithms, surgical robots expedite the decision-making process and ensure that the surgery is executed with optimal precision and efficacy. In addition to supplying real-time guidance and assessing imaging data, surgical robots excel in guaranteeing that procedures are carried out with the utmost precision. Leveraging cutting-edge robotics technology, these sophisticated robots can execute intricate maneuvers with unparalleled accuracy, ensuring that the surgical outcomes are as successful as conceivable. This unprecedented level of precision not only diminishes the risk of complications during the surgery but also elevates the overall standard of care delivered to the patient. The integration of surgical robots into breast cancer surgeries epitomizes a momentous advancement in the sphere of healthcare, affording a vast array of advantages to both patients and surgeons alike. By furnishing real-time guidance, scrutinizing imaging data, and ensuring utmost precision during procedures, these robots have emerged as indispensable instruments for attaining favorable outcomes in breast cancer surgeries.[13,14] As the capabilities of surgical robots continue to advance and develop, they are anticipated to play an increasingly pivotal role in the forthcoming landscape of healthcare, spearheading a revolution in the methodology of surgeries and ultimately enhancing the quality of care dispensed to patients.

Remote monitoring for breast diseases

Remote monitoring is a critical component in the management of breast disease, with AI technologies playing a transformative role in healthcare. The integration of AI-powered remote monitoring systems allows healthcare providers to closely monitor patients' health data, track symptom progression, and ensure treatment adherence from a distance.[15,16] This innovative approach facilitates timely interventions, personalized care, disease progression prediction, and tailored treatment recommendations based on individual patient health data and medical history. The utilization of AI in remote monitoring systems has significantly improved the efficiency and effectiveness of breast disease management.[17,18] Through continuous data collection and analysis, AI algorithms can identify patterns and trends indicating disease progression or treatment non-compliance. This proactive approach enables healthcare providers to intervene early, adjust treatment plans accordingly, and optimize patient outcomes. Moreover, AI-powered remote monitoring systems have the capacity to deliver personalized care by leveraging patient-specific data like genetics, lifestyle factors, and treatment history. By utilizing this information, AI algorithms can generate customized recommendations for disease management and treatment options.[19–21] This personalized approach enhances patient outcomes and elevates the quality of care provided by healthcare providers. Additionally, AI-powered remote monitoring systems can accurately predict disease progression by analyzing extensive data from various sources, including patient health records, imaging studies, and genetic testing results. These AI algorithms can forecast the likelihood of disease progression and recommend suitable interventions, empowering healthcare providers to make informed decisions about treatment planning and resource allocation for improved patient outcomes.

The integration of AI in remote monitoring systems has the potential to revolutionize the management and treatment of breast diseases. By harnessing the capabilities of AI algorithms, healthcare providers can streamline patient care processes, enhance decision-making abilities, and optimize treatment outcomes. This technological advancement not only ensures personalized and timely care for patients but also enhances the efficiency and effectiveness of healthcare delivery. A key advantage of AI-powered remote monitoring systems is their ability to boost patient engagement and adherence to treatment plans. Through real-time feedback on health status, symptom progression, and treatment compliance, these systems empower patients to actively participate in their care. By providing personalized reminders, alerts, and educational resources, AI-powered remote monitoring systems help patients stay on track with their treatment plans and achieve better health outcomes. Furthermore, AI-powered remote monitoring systems have the potential to elevate the overall quality of care provided to patients with breast diseases. By continually analyzing patient data and offering insights into disease progression and treatment options, these systems enable healthcare providers to make informed and personalized decisions. This results in better treatment outcomes, reduced healthcare costs, and enhanced patient satisfaction. As a result, AI-powered remote monitoring systems are reshaping the management of breast diseases by enabling healthcare providers to monitor patient health data, predict disease progression, and recommend personalized treatment options. Through the integration of AI algorithms, healthcare providers can deliver more efficient, effective, and personalized care to patients with breast diseases. These technological advancements have the potential to enhance patient outcomes, increase patient engagement, and improve the quality of care provided by healthcare providers.

Results

The implementation of surgical robots in surgeries for breast cancer has had a significant impact on the field, greatly improving precision, accuracy, and overall outcomes. These robots offer real-time guidance to surgeons, analyze imaging data, and ensure the utmost accuracy during procedures. As a result of these advancements, surgical robots have become essential tools for successful breast cancer surgeries. The utilization of advanced robotics technology has steadily increased in recent years, showcasing the growing recognition of their benefits in enhancing patient care. On a similar note, the introduction of AI-powered remote monitoring systems in the management of breast diseases has completely transformed the healthcare industry. These systems continuously collect and analyze data, allowing for the tracking of symptom progression, prediction of disease advancement, and the recommendation of personalized treatment options based on individual patient data. The integration of AI algorithms has greatly improved the efficiency and effectiveness of remote monitoring, leading to more timely interventions, optimized treatment plans, and ultimately, better patient outcomes. As a result, the evidence shows that the incorporation of surgical robotics and AI-powered remote monitoring systems in breast disease management has increased the quality of care provided to patients. These technological innovations have not only enhanced precision, accuracy, and outcomes in surgeries but have also streamlined patient care processes, improved patient engagement, and provided personalized treatment options. The future of healthcare is on the brink of further advancements in surgical robotics and remote monitoring, leading to more efficient, effective, and personalized care for patients with breast diseases.

Discussion

Conversations within the medical community have highlighted the recent advancements in surgical robotics for breast cancer procedures, which have drastically improved patient outcomes by enhancing precision and quality of care. Incorporating AI into surgical robots has revolutionized the way surgeries are performed, providing real-time guidance to surgeons and ensuring utmost precision during procedures. These robots have proven to be essential in analyzing imaging data and improving the efficiency and success rates of breast cancer surgeries. Similarly, AI-powered remote monitoring systems have played a crucial role in managing breast diseases by allowing healthcare providers to monitor patient health data and predict disease progression from a distance. By analyzing patient-specific data and generating personalized treatment recommendations, these systems have significantly improved the effectiveness of disease management. The study emphasizes the transformative potential of AI-powered remote monitoring systems in delivering personalized care and improving patient outcomes for individuals with breast diseases. The integration of surgical robotics and AI-powered remote monitoring systems represents a significant advancement in healthcare technology, enhancing precision, accuracy, and overall patient care. These innovations have streamlined patient care processes, increased patient engagement, and provided tailored treatment options. As technology continues to evolve, there is immense promise for more efficient, effective, and personalized care for patients with breast diseases. Continued research and development in this rapidly evolving field are crucial for advancing breast disease management and improving patient outcomes. Incorporating robotics and monitoring technology into healthcare, especially for breast disease management, presents a range of advantages but also significant challenges that different healthcare systems globally must contend with. Here are some notable drawbacks to think about: Firstly, the costs associated with these technologies can be prohibitive. The initial investment for robotic systems and advanced monitoring tools can be substantial, which can make it difficult for healthcare systems with limited resources to adopt them. Additionally, ongoing maintenance costs can further strain budgets, particularly in healthcare settings that are already underfunded. Another critical issue is the need for skilled professionals to operate these technologies effectively. Healthcare workers may require extensive training and continuous education to use robotic systems and understand the data generated by monitoring devices. This need can intensify existing workforce shortages, as many regions already struggle to find qualified medical staff. There are also concerns about equitable access to these advanced technologies. Rural and underserved populations might find it challenging to access cutting-edge robotic treatments, which could lead to disparities in healthcare quality compared to urban areas. Economic factors could exacerbate this issue, as individuals from lower socioeconomic backgrounds may lack access to the latest technologies, resulting in unequal health outcomes. Integrating new robotic technologies into existing healthcare systems can prove difficult as well. Compatibility issues with current health information systems may hinder efficient data sharing and patient management. Furthermore, some clinicians may be resistant to adopting new technologies due to a lack of familiarity or misplaced trust, which could impede the integration process.

Data privacy and security pose additional concerns. The increased reliance on robotic and monitoring systems heightens the risk of data breaches if patient information is not managed securely. Healthcare systems need to comply with complex regulations concerning data privacy and cybersecurity, which can delay the adoption of these innovations. Moreover, there is the danger of becoming overly dependent on technology. Clinicians might start to rely too heavily on robotic systems for decision-making, which could undermine their clinical judgment and patient evaluations. These technologies also have limitations when it comes to interpreting complex clinical situations that often require human intuition. Job displacement is another potential downside. While robotics can boost efficiency, there are concerns about reduced demand for certain healthcare roles, which could negatively impact staff morale and job security. Further complicating the situation are mixed results in terms of the effectiveness of robotic interventions in managing breast diseases. Studies show varying success rates, creating uncertainty for both patients and healthcare providers about the best treatment options. The lack of universally accepted standards in implementing these technologies can lead to inconsistencies across different healthcare systems. Cultural and ethical aspects also come into play. Different cultural attitudes towards robotic interventions can influence patient acceptance and adherence to treatment. Ethical dilemmas arise concerning the implications of using technology in such sensitive areas as breast disease management, particularly regarding the balance between technology and human-centered care.

Additional significant effects of the use of the surgical robots and remote monitoring systems in the breast health are represented by the energy effects. The use of AI in the medical field is reshaping how breast diseases are treated, particularly through surgical robotics and remote monitoring, which can have a considerable effect on energy use and public health. For the surgical robotics, the introduction of robotic systems in breast surgery is aimed at improving precision and shortening recovery periods. This approach often results in shorter hospital stays and less energy required from healthcare facilities since these minimally invasive procedures typically need fewer resources for lighting and sterilization. Additionally, robotic technologies can reduce the time spent in operating rooms, which lessens not only energy consumption but also the use of anesthesia—which has environmental implications due to certain anesthetic gases emitting greenhouse gases. Moreover, while there might be high energy demands in producing and maintaining surgical robots, the efficiencies gained during their use can lead to overall energy savings compared to conventional surgical methods. With AI-driven imaging technology, early detection of breast diseases can significantly enhance patient outcomes, potentially lessening the strain on healthcare resources in the long run. This technology can also help hospitals manage more patients without proportionately increasing their energy consumption. On the other hand,

remote monitoring technologies, including wearables, also influence energy use. Though these devices need power to function, they contribute to lower energy consumption over time by minimizing in-person visits and hospital appointments. This transition to virtual consultations can lower the carbon impact associated with transportation and facility operation.[22,23] In Fig. 2, we illustrate the main limitations of the use of the surgical robots and remote monitoring for breast health.

The AI processes driving remote monitoring do require energy, especially during data processing and storage. However, the adoption of energy-efficient data centers can mitigate these demands. Engaging patients in self-monitoring can result in fewer clinical visits, thereby reducing energy expenditures. With regard to public health, remote monitoring enhances access to care for patients with breast diseases, especially in areas where healthcare is limited. By reducing the necessity for travel, these technologies can positively affect environmental impact and promote preventive care. Furthermore, employing remote monitoring allows healthcare systems to better allocate resources, which may lead to lowered operational costs and energy use in hospitals. As the healthcare sector contributes notably to global carbon emissions, leveraging AI technologies can be vital in addressing climate change. Improvements in how breast diseases are treated can help lower the sector's carbon footprint by enhancing resource management. While hospitals might see significant initial investments in these technologies, the long-term savings from operational efficiencies could be redirected towards advancing public health efforts, research, and community health initiatives.

Conclusions

In this article, we showed how AI is revolutionizing the identification and diagnosis of breast diseases, particularly breast cancer. The integration of AI technologies, such as surgical robots and remote monitoring systems, has significantly improved the accuracy, efficiency, and effectiveness of breast disease management. We demonstrated that surgical robots equipped with AI algorithms provide real-time guidance to surgeons, analyze imaging data, and ensure meticulous precision during procedures. This advancement has elevated the quality of care delivered to patients, resulting in successful outcomes in breast cancer surgeries.

As we venture further into the realm of AI technology for breast diseases, we can observe the significant influence they have on transforming healthcare methods. In our investigation of AI-driven remote monitoring systems, we have seen the impressive capabilities they offer in enabling healthcare providers to closely track patient health data, anticipate disease progression, and suggest tailored treatment options. By utilizing AI algorithms, healthcare providers are able to enhance patient outcomes, promote increased patient involvement, and enhance the overall quality of care provided to patients with breast diseases. The incorporation of AI technology into healthcare practices is paving the way for more streamlined and effective patient care, ultimately resulting in improved health outcomes and patient satisfaction. As we consider the progress made in leveraging AI for breast diseases, it is clear that these advancements are reshaping the healthcare industry. The personalization and accuracy that AI technology provides are transforming how healthcare providers approach the diagnosis, treatment, and control of breast cancer. Through the integration of AI-driven solutions, we are observing a shift towards more personalized and tailored healthcare strategies that meet the unique needs of each patient.

Looking forward, we are optimistic about the potential of utilizing AI technology to further improve the quality of life for those impacted by breast cancer. As AI continues to progress, we anticipate even greater strides in diagnostic precision, treatment effectiveness, and patient care. The opportunity for AI to revolutionize the management of breast diseases is vast, and we are thrilled to be leading this transformative journey. In summary, the advancements in AI technology for breast diseases are bringing about positive changes in the healthcare field. Through our ongoing exploration and utilization of AI-powered solutions, we are unlocking new opportunities to enhance patient care, outcomes, and experiences. Incorporating robotics and monitoring technology in breast disease management offers efficiency and improved patient outcomes but presents challenges such as high costs, workforce shortages, and disparities in access. Data privacy concerns and potential job displacement are critical issues. Despite these drawbacks, long-term energy savings and enhanced resource management can benefit public health. By harnessing the power of AI to improve the precision and individualization of healthcare practices, we are paving the way to a brighter future for individuals facing breast cancer. Together, we are at the forefront of a healthcare revolution that is redefining care standards and ultimately enhancing the lives of patients globally.

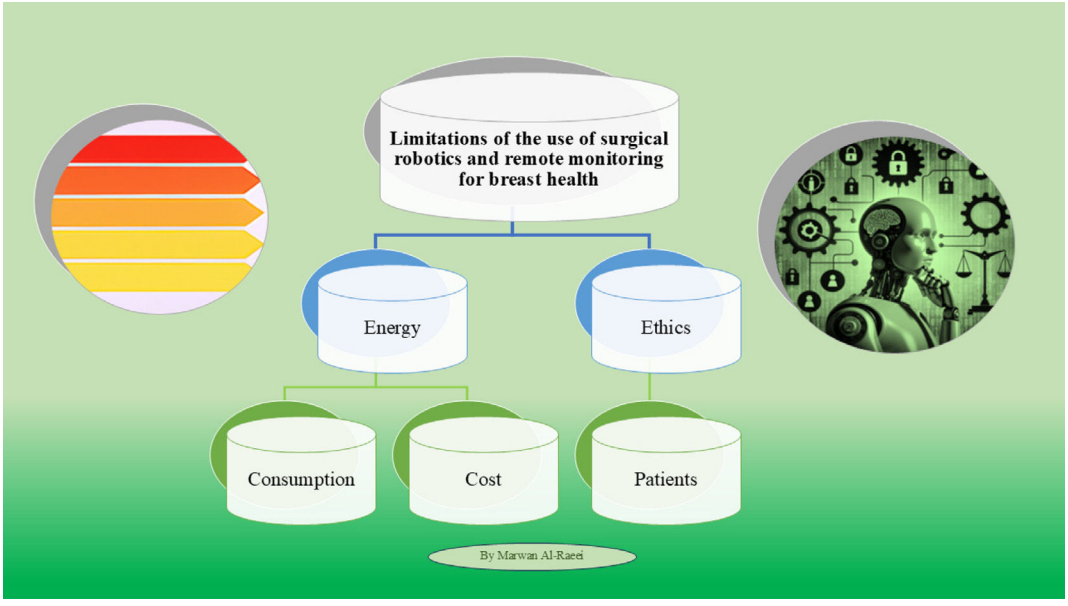

Fig. 2. The main limitations of using the artificial intelligence robots for breast diseases.

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Availability of data and materials

All data are included in the manuscript.

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Authors' contributions

All authors of the article (MA) are responsible to the design and implementation of the research to the analysis of the results and to the writing of the manuscript.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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