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Review

Artificial Intelligence Applications in Global Surgery and Surgical Nursing

Küresel Cerrahi ve Cerrahi Hemşireliğinde Yapay Zeka Uygulamaları

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ABSTRACT

Artificial Intelligence technologies, which show a rapid progress today, show an effective and successful progress in the field of surgery as in every field. This study aimed to reveal the effects of Artificial Intelligence technologies and applications on global surgery and surgical nursing. In the light of the data obtained by searching the literature in Google Scholar, Pubmed, Scopus, Web of Science databases, the benefits and limitations of artificial intelligence technologies in the field of global surgery and surgical nursing were reviewed. It is discussed that artificial intelligence technologies, which are widely used in the surgical field for surgeons, are very successful in practice but may cause some ethical problems. In terms of surgical nursing, it is seen that artificial intelligence applications are limited, they are successful in student education. These technologies bring some new responsibilities to nurses in the clinic. Although Artificial Intelligence technologies are widely used in surgery, their use in the field of surgical nursing is not yet at the desired level. In order to increase the use of these technologies within the framework of ethical principles in the field of nursing, necessary trainings should be provided and nurses should have knowledge in this field.

Keywords: Artificial Intelligence, Surgery, Surgical Nursing

ÖZ

Günümüzde hızlı bir ilerleme gösteren yapay zeka teknolojileri, her alanda olduğu gibi cerrahi alanında da etkili ve başarılı bir ilerleme göstermektedir. Bu çalışma, yapay zeka teknolojileri ve uygulamalarının küresel cerrahi ve cerrahi hemşireliği üzerindeki etkilerini ortaya koymayı amaçlamıştır. Google Scholar, Pubmed, Scopus, Web of Science veri tabanlarında literatür taraması yapılarak elde edilen veriler ışığında, yapay zeka teknolojilerinin küresel cerrahi ve cerrahi hemşireliği alanındaki yararları ve sınırlılıkları gözden geçirilmiştir. Cerrahi alanda ve cerrahlar için yaygın olarak kullanılan yapay zeka teknolojilerinin uygulamada çok başarılı olduğu ancak bazı etik sorunlara neden olabileceği tartışılmıştır. Cerrahi hemşireliği açısından ise yapay zeka uygulamalarının sınırlı olduğu, öğrenci eğitiminde başarılı olduğu ve bu teknolojilerin klinikte hemşirelere bazı yeni sorumluluklar getirdiği görülmektedir. Yapay zeka teknolojileri cerrahi alanında yaygın olarak kullanılmasına rağmen cerrahi hemşireliği alanında kullanımı henüz istenilen düzeyde değildir. Hemşirelik alanında etik ilkeler çerçevesinde bu teknolojilerin kullanımının arttırılması için gerekli eğitimlerin verilmesi ve hemşirelerin bu alanda bilgi sahibi olması gerekmektedir.

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Hemşirelik Bilimi Dergisi
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INTRODUCTION

Artificial intelligence (AI) is defined as machine-based systems that perform human-defined target tasks to make predictions, recommendations or decisions that affect their environment so that cognitive processes associated with human intelligence can be executed (Amin et al., 2024; Guni et al., 2024; World Health Organization [WHO], 2021). The rapid growth in AI applications requires an understanding of how these technologies can be used to deliver safer, more efficient and more cost-effective care (Bellini et al., 2022).

Major advances and developments in computer technologies have played a major role in the development of the basic technologies required for the emergence of AI, which is rooted in many fields such as philosophy, psychology, linguistics, robotics and statistics (Hashimoto et al., 2018). AI imposes human capabilities on machines, such as problem solving, object and word recognition, inference from situations and decision making (Bellini et al., 2022). Therefore, this process starts with the developers of the AI system inputting the available data into the system and the system 'learning' this data. The system's learning experience enables AI to understand, communicate, make decisions and draw inferences in a similar way to humans, or even better than humans (Keles, 2022). AI technologies include many disciplines such as 'Machine learning', 'Deep learning', 'Neural networks', 'Rational agents' (Hashimoto et al., 2018; Keles, 2022). It has been observed that subtypes of AI have the potential to be clinically useful (Guni et al., 2024).

'Machine learning', which enables machines to learn and make predictions by recognizing patterns identified in their systems, is a subset of AI that enables the medical team to better care for patients through accurate diagnosis and treatment (Amin et al., 2024; Guni et al., 2024; Hashimoto et al., 2018). 'Machine learning' is also said to be very useful in identifying subtle patterns in large datasets, using techniques that allow for more indirect and complex relationships and multivariate effects than traditional statistical analysis (Hashimoto et al., 2018).

'Deep learning', which uses neural networks to analyze large datasets and solve complex problems, is a more advanced subset within machine learning. It can be defined as neural networks that contain multiple hidden layers with higher processing capability (Bodenstedt et al., 2020; Guni et al., 2024; Li et al., 2021). One of the most important applications of deep learning in identifying complex patterns is its diagnostic performance in medical imaging (Aggarwal et al., 2021; Guni et al., 2024).

Inspired by biological nervous systems, 'neural networks' receive data inputs similar to dendrites in neurons, process them in layers that perform calculations similar to the functions of axons and transmit the output to the next neuron, while the connections between neurons are classified according to different input-output maps of the network corresponding to tasks such as pattern/image recognition and data classification (Hashimoto et al., 2018). At this stage, 'Rational agents' appear as a piece of software that bases the decision on AI (i.e. an artificial brain) (Keles, 2022).

If we explain the working principle of AI with an example; when a machine is to be programmed to recognize the outlines of the heart in magnetic resonance imaging, it is first necessary to prepare a large number of images of the heart and other organs and label the images as “heart” and “not heart”. A simple program is prepared that can analyze the images and distinguish them according to some features. Next, the labeled and segmented images are fed into the deep learning algorithm and the labeled images are processed. As the learning progresses, images labeled as “heart” activate neurons on a specific pathway in the artificial brain, and “not heart” images trigger other neuron pathways. After processing enough images, this artificial brain can now distinguish between an image of a heart and an image of another organ. This entire process is called “Machine Learning”. These tasks are not only limited to recognizing organs; they are also important for distinguishing

Hemşirelik Bilimi Dergisi
2025, 8(3), 413-427
Doi: 10.54189/hbd.1606325

between healthy cells and cancer cells, and helping to classify lesions as normal or abnormal, benign or malignant (Castiglioni et al., 2021). In this direction, there are studies indicating that deep learning models are used to identify safe and dangerous areas in procedures such as laparoscopic cholecystectomy (Madani et al., 2022), cataract surgery (Garcia et al., 2022), laparoscopic sleeve gastrectomy (Hashimoto et al., 2019) and aneurysm repair (Li et al., 2022). In addition, real-time analysis of laparoscopic video in a sleeve gastrectomy surgery provided automatic identification with 92.8% accuracy (Volkov et al., 2017), providing evidence that AI can be used surgically to identify or predict adverse events for intraoperative clinical decision support (Hashimoto et al., 2018). It is stated that it is possible to produce many applications in this way (Castiglioni et al., 2021; Keles, 2022).

Use of Artificial Intelligence in Surgery

AI applications have gained considerable attention in the last decade, with significant advances in testing and developing their clinical use (Guni et al., 2024). The ability of AI technologies to quickly and accurately examine large datasets and detect connections that the human mind cannot perceive has made them particularly useful in healthcare (Bellini et al., 2022).

In the surgical field, the first computer-assisted surgery systems emerged in the early 80s and these systems helped to guide surgical procedures using real-time data with preoperative images (Stark et al., 2024), and in recent years, AI technologies, which are frequently used in surgical applications in operating rooms, have been used as a very important intraoperative tool in different fields of surgery such as general surgery, thoracic surgery, urology, neurosurgery and orthopedic surgery, cardiothoracic and vascular surgery, although they cannot replace the surgeon yet (Amin et al., 2024). It is known that the use of augmented reality applications and surgical robots, especially guided by artificial intelligence algorithms, provides real-time assistance to surgeons during surgery, enabling the surgeon to perform applications with precise and stable movements, thus reducing possible errors (Fan et al., 2023; Stark et al., 2024).

Artificial Intelligence Technologies Used in Surgery

The most outstanding achievement and application of artificial intelligence is that the latest technological systems used in the surgical field have been developed with artificial intelligence. AI technologies have enabled the development of 3D printing technologies, virtual reality, augmented reality and mixed reality technologies, especially robotic technologies (Keles, 2022). In this direction, we can examine these technologies as 'AI-containing' (driven by AI algorithms) and 'AI-enhanced' applications.

AI Containing Technologies

- **Robotic Technologies/Autonomous Robots and Artificial Intelligence:** Today, the use of robotic technologies has become a more preferred method by surgeons and patients in surgical applications (Yılmaz & Ölçer, 2021).

There are a number of reasons for the development of autonomous surgical robots through artificial intelligence. First of all, autonomous robots can perform repetitive and delicate surgical tasks more precisely and accurately than humans without physical limitations, reducing errors caused by surgeon fatigue and burnout. Another important reason for the development of these robots is that they are thought to provide expanded access to surgical care and to be able to perform complex surgical procedures in situations such as war zones, disaster zones and extraterrestrial space travel, where human surgical expertise is unavailable or grossly inadequate. In this direction, most robotic surgical interventions are known to provide patients with faster recovery times through smaller incisions (Hamilton, 2024).

Hemşirelik Bilimi Dergisi
2025, 8(3), 413-427
Doi: 10.54189/hbd.1606325

- **Da Vinci robotic surgical systems:** The combination of AI and surgical systems began in 2000 when the US Food and Drug Administration approved the applicability of the "da Vinci" Surgical System in clinical surgery. While the systems used as an aid to surgical applications before this process could not work without human control, the more accurate and clearer image of da Vinci robotic surgery applications enabled comfortable and even remote operation with these applications. Therefore, surgical treatment with robots has become more minimally invasive and has provided high surgical success and low complication rates in the surgery of many organs (Froiio et al., 2022; Keles, 2022; Tae, 2020). Remote surgery applications have come to the agenda, especially in situations such as the COVID-19 period, where the contact between surgeon and patient must be maintained for public health. At this point, it is known that surgeons can easily and successfully perform robotic surgery applications in which they can remotely control surgical instruments, receive real-time sensory information that is critical for decision-making and intervention, and transmit motor applications to robots with the help of a control unit between the robot and the surgeon (Amin et al., 2024; Öztepe Yeşilyurt, 2023a; Uslu et al., 2019). The use of da Vinci robotic surgery systems, which have developed rapidly over the years, has become quite widespread in areas such as general surgery, orthopedic surgery, thoracic surgery, urological surgery, cardiovascular surgery, gynecological surgery, plastic surgery and otolaryngology surgery (He et al., 2021; Kılınç Akman et al., 2022; Öztepe Yeşilyurt, 2023a). Although robotic surgery systems are not accessible in every country, it is seen that there is a rapid increase in their use (Kilinc Akman et al., 2022; Öztepe Yeşilyurt, 2023a) and better surgical results are achieved with the use of these systems (Kang et al., 2016; Okgun Alcan et al., 2019). With the addition of 5G technology to these systems, it is stated that remote telerobotic surgery applications can be performed in space, on the highest peaks of mountains, and even in the depths of oceans with the realization of telesurgery systems (Mcintyre et al., 2018; Niu, 2023).
- **Cyberknife:** It is an image-guided system developed for stereotactic radiotherapy applications that is mounted on a robotic arm, contains a linear accelerator as an ionizing radiation source, and aligns the treatment beam to the target area to find anatomical points associated with the target area without a frame used to position the target area (Yılmaz & Ölçer, 2021). This treatment method aims to minimize damage to healthy tissues and eliminate malignant cells (Chmiel, 2020). With Cyberknife, especially cancerous tissues in the brain or tumors in a specific location can be destroyed (Bhandari et al., 2020). It is also stated that the CyberKnife system and stereotactic radiosurgery can be applied effectively and safely, especially for the treatment of metastatic brain tumors (Wowra et al., 2012). In addition, there are results obtained for stopping tumor progression by using the CyberKnife system in brain metastases of multiple and large tumors (Wowra et al., 2012) and studies on the applicability of CyberKnife radiosurgery applications in areas such as facetogenic back pain, obsessive compulsive disorder and cardiac ablation are still ongoing (Yılmaz & Ölçer, 2021).
- **MAKO THA systems (Robotic arm assisted surgery):** When total hip replacement surgery is decided with this system, computed tomography of the pelvis and both lower extremities, from the hip to the knee, is performed to size the implants, and the data obtained are uploaded to the computer to create a three-dimensional model of the pelvis and both lower extremities, which is the most important step in preoperative planning. Thus, thanks to the anatomical data and the patient's specific pelvic reference points, the placement of the component at the appropriate angle and position is planned (Tuncay & Erdem, 2022; Yılmaz & Ölçer, 2020). In the opposite iliac wing, receiving eyes called 'array', which instantly report the position of the bones in space to the computer during the operation, are placed on the opposite iliac wing, and by making the appropriate surgical opening, the bones are mapped with an electronic pen-shaped device and this map is matched with the tomography sections taken preoperatively on the computer. This allows the robotic system to define the level at which the femoral neck incision will be made and the angle at which the acetabular component will be placed. As a result, the surgeon can observe all the stages and the surgical site during the operation, and can provide three-dimensional control from the

Hemşirelik Bilimi Dergisi
2025, 8(3), 413-427
Doi: 10.54189/hbd.1606325

computer screen, preventing further soft tissue damage. After the femoral neck incision and acetabulum are prepared to the appropriate extent, the components are placed and the hip range of motion and the length difference between the extremities are evaluated and the surgery is completed (Tuncay & Erdem, 2022).

- **YOMI:** This robotic surgical device, which provides guidance to surgeons, provides software to guide the planning and orientation of instruments during dental implant (Wu et al., 2019). In addition, this system, which provides surgically repeatable haptic robotic guidance, facilitates the application by controlling the appropriate position, depth and angular shape for osteotomy in implant applications (Natarajan, 2018; Wu et al.,2019).
- **Smart Knife Technology (iKnife):** Considering the traditional methods to detect cancerous tissues, samples taken from the patient can be evaluated in seconds with the smart knife (iKnife) technology compared to the analysis process of a sample in pathology laboratories, which takes 20-30 minutes. iKnife is a technology that stores and analyzes the necessary information about the excised vaporized tissue together with the electrosurgical system used to cut or vaporize the tissue using electricity (Yılmaz & Ölçer, 2020). With the use of this technology, it has been observed that cancerous tissues in the brain, breast, colon and ovarian regions containing tumors can be distinguished from normal tissues with a very high accuracy (Yılmaz & Ölçer, 2021; Tzafetas et al., 2020).

AI Enhanced Technologies

- **3D Printing Technologies and Artificial Intelligence:** 3D printing is a type of rapid prototyping technology that partially uses AI (Keles, 2022), and is known as the process of solid material output of a 3D model, which is taken from anywhere ready-made with artificial intelligence technology or created personally, from a 3D printer by sequencing two-dimensional layers on top of each other (Aydın & Küçük, 2017; Keles, 2022; Öztepe Yeşilyurt, 2023b). 3D printers realize the production of three-dimensional objects created with computer support and control, using only as much raw material as needed (Arslan et al., 2018; Öztepe Yeşilyurt, 2023b). 3D printing materials are widely used in different fields of surgery such as cardiothoracic surgery, neurosurgery, oral and maxillofacial surgery, orthopedics, plastic surgery, transplantation, urology and vascular surgery (Aimar et al., 2019; Keles, 2022; Liu et al., 2021; Oztepe Yesilyurt, 2023b). It is known that these materials are used in medical education, preoperative planning, and intraoperative orientation in the surgical field, as well as enabling tissue-organ and surgical instrument production, helping surgeons to think faster and cope with technical difficulties more easily, and are widely used to increase the success of surgery (Keles, 2022; Liu et al., 2021; Öztepe Yeşilyurt, 2023b; Tejo-Otero et al., 2020). It is believed that 3D printing technologies, which contribute greatly to the development of the field of surgery today and require more human intervention, will one day reach all intelligence (Keles, 2022). It is already reported that these technologies aim to print all living organs in the future (Keles, 2022; Liu et al., 2021).
- **Virtual Reality, Augmented Reality and Mixed Reality Technologies and Artificial Intelligence:** These are so-called metaverse applications (Yurttaş & Kabak Solak, 2023) that partly use AI technology (Creighton et al., 2019) to reconstruct clinical data and create new types of digital holographic images. Virtual reality is a type of technology that allows surgeons to practice and improve their surgical skills by using a pure virtual digital image created by an intelligent computer algorithm without causing a serious operational error. However, it cannot be applied in real surgery due to the lack of real-world experience (Creighton et al., 2019). Augmented reality technology is known as technology systems that are created by transforming patient data and virtually recreating the critical area, adding the virtual image to the real visual world, enabling the recognition of complex anatomical structures before or during surgery and guiding surgeons (Creighton et al., 2019). In the augmented reality application, artificial intelligence-based 'tracking systems' are usually allowed to “match” the patient's anatomy with the radiographic database, and the patient's anatomy is projected into the intraoperative space (Hamilton, 2024).

Hemşirelik Bilimi Dergisi
2025, 8(3), 413-427
Doi: 10.54189/hbd.1606325

These guidance systems have been effective in finding suspicious lesions in colonoscopy (Mitsala et al., 2021), identifying suspicious, infiltrative lesions (Tokat et al., 2022), performing complete resection of intraparenchymal neoplasms (Awuah et al., 2024), and in orthopedic surgery, reducing intraoperative time and improving outcomes (Shaikh et al., 2023). However, due to the bulkiness of augmented reality equipment, the use of these applications in surgery has been limited (Hamilton, 2024; Hu et al., 2019). Mixed reality technologies, which appear as the latest digital holographic imaging technology, are systems consisting of portable equipment, a real-time interactive location and live visual experiences, designed as a closed combination of virtuality and reality with real-time interaction and exact matching features. With mixed reality applications, the surgeon can immerse himself in the complex world of surgery, create a better treatment program and improve doctor-patient communication (Wu et al., 2018). This new technology has been used for intraoperative guidance in various surgical applications such as liver, spine, orthopedics, kidney and skull surgeries, shortening the operation time and improving the accuracy and safety of surgery (Yoshida et al., 2019). Compared to 3D printing technologies, mixed reality technology seems to be more advantageous in terms of simultaneity as well as providing more accurate navigation, considering that 3D printing production can take several hours (Keles, 2022; Mehta & Devarakonda, 2018).

Benefits of Artificial Intelligence in Surgical Practice

Today, AI technologies used in various medical fields are effectively used in diagnosing, monitoring and prognosis determinations of diseases, automating the management of patients' treatment plans and appointment reminders, and facilitating decision-making processes (Keles, 2022). These technologies, which are used in all stages of surgery, have many benefits.

- **Preoperative Planning and Risk Prediction:** Thanks to AI technologies, a mathematical description of a single individual can be reached among the unimaginable calculations of millions of cases, and the conditions that may provide an advantage in better response to the surgery to be performed on this individual can be determined (Hamilton, 2024). It is also stated that this technology, which can also provide access to personal weaknesses that may pose risks and lead to disaster before and during surgery, has features that can tell surgeons the likelihood of sepsis developing in a patient (Sood et al., 2017), the likelihood of the same patient leaving the ventilator in intensive care (Stivi et al., 2024), survival (Binkley et al., 2019) and the likelihood of the patient dying (Griffin, 2021). It is stated that AI mostly performs preoperative analysis of patients' medical histories, imaging data and predicted analysis of the intervention in orthopedic surgical interventions and minimizes possible errors with simulations, reducing risks and providing better surgical outcomes (Lambrechts et al., 2022; Stark et al., 2024).
- **Intraoperative Guidance:** The advances made by AI technologies during surgery include predicting the duration of the intervention, recognizing gestures and workflow, performing video analysis and cancer detection during surgery, providing endoscopic guidance, performing interventions such as knot tying, and automatic recording of bone in orthopedic surgery (Hamilton, 2024). The use of AI in oncological surgery has been proven to make the detection of tumor cells 20% more sensitive (Jermny et al., 2016). The use of AI technologies in interoperative guidance for resection of malignant gliomas, one of the most common intracranial tumors, has been shown to improve tumor resection (Wei et al., 2022). In AI technology developed for thyroidectomy, AI performance was further improved by applying geometric transformation and image inpainting enhancement methods for accurate identification and preservation of parathyroid glands, and the most effective method was proven to be inpainting imaging (Ku et al., 2021). In the development of a deep learning model to be used in endovascular aneurysm repair (EVAR), images obtained from 110 patients were used to determine the suboptimal placement

Hemşirelik Bilimi Dergisi
2025, 8(3), 413-427
Doi: 10.54189/hbd.1606325

of EVAR and to prevent risks that may develop, and the AI guide was trained and found to be 97% successful in detecting the violation in the renal arteries (Li et al., 2024). Another study proved that AI developed for laparoscopic cholecystectomy was successfully used to identify the anatomy in the surgical field (Madani et al., 2022). Recognition of hepatic vessels during parenchymal resection of the liver is an important part of laparoscopic surgical technique, and it has been reported that AI guidance would be beneficial in minimally invasive surgery and liver resection (Une et al., 2024). In addition, for orthopedic surgery, it is mentioned that bone records obtained from preoperative scans with AI technology give very good results in ensuring patient position and correct alignment of the surgical site (Liu & Baena, 2020).

- **Postoperative Care:** With each surgical intervention, AI technologies collect more data, improve their algorithms and reach various insights (Stark et al., 2024). Therefore, AI algorithms can provide better management of the postoperative process by predicting postoperative complications, providing early intervention and preventing risks that may develop (Loftus et al., 2020). Because postoperative complications increase mortality and morbidity, prolong hospitalization, and cause significant financial burdens in the provision of health services (Guni et al., 2024; Ludbrook, 2022). In this direction, it is known that an AI model has been developed to identify anastomotic leaks that may develop after anterior resections (Wen et al., 2021). It is also stated that wearable AI technologies developed to assess the risks of postoperative infection, the effectiveness of personalized therapy applications and remote monitoring of patients' feelings help to guide rehabilitation and postoperative care (Tariq et al., 2023). In addition, AI algorithms have been developed to predict surgical site infections (Azimi et al., 2020), complications after bariatric surgery (Cao et al., 2019; Nudel et al., 2021) and postoperative bleeding (Chen et al., 2018), but this technology is still far from clinical applications (Guni et al., 2024).
- **Effective Discharge Planning and Patient Follow-up:** Making a personalized and structured discharge plan for patients shortens the length of hospital stay, reduces hospital readmissions and increases patient satisfaction (Gonçalves-Bradley et al., 2022). In a study conducted in this direction, supervised learning models developed with AI technology showed very high performance in predicting the need for hospitalization after the second postoperative day in a hospital in the Netherlands, in creating effective and safe discharge plans for patients (van de Sande et al., 2021). In another study, an automated AI-powered patient tracking system was developed for postoperative orthopedic patients and it was reported that the system successfully tracked patients and received higher feedback than human-led patient tracking (Bian et al., 2020). Future studies need to focus on the impact of these systems on patient satisfaction and whether they have an impact on patient readmission or re-intervention rates (Guni et al., 2024).
- **Education and Training:** During the COVID-19 pandemic, it was necessary to develop systems that would enable healthcare students to receive distance education and attend classes, as in all fields. In this process, with the use of new technologies such as augmented reality and simulation applications, education has become more accessible internationally (Hamilton, 2024).

Today, operative videos provide a rich source of information for students and trainee surgeons to learn from. Using machine learning from AI applications, surgical videos can explain instruments, movements, errors and anatomy, detail the surgical steps of a procedure, and provide real-time feedback and guidance (Kawka et al., 2022). By integrating the technology developed with machine learning into VR and AR-based simulations, an invaluable complementary application for surgical training has been achieved (Guni et al., 2024).

In addition, ChatGPT has been successfully used in public spaces thanks to its expressive generation capabilities (Clusmann et al., 2023), and Large language models (LLMs) have been successfully used to pass US medical licensing exams by providing human-like outputs (Kung et al., 2023). Used to automate training tasks, LLMs enable the provision of

Hemşirelik Bilimi Dergisi
2025, 8(3), 413-427
Doi: 10.54189/hbd.1606325

instructional support, grading of assessments, prediction of student performance, real-time feedback and content generation (Yan et al., 2023). LLMs have the potential to be a fundamental tool in surgical practice and can be easily used by students and trainees to easily access educational resources and clinical information (Guni et al., 2024).

Challenges and Potential Shortcomings of Artificial Intelligence in Practice

Although artificial intelligence applications have advantages, the fact that human-oriented decision-making and applications will be carried out in the diagnosis and treatment process brings some risks (Khanzode & Sarode, 2020; Tarcan et al., 2024). Artificial intelligence technologies, which generally use large amounts of data, carry cybersecurity risks in terms of management, data bias and drift, patient safety, privacy and security of data (in terms of malicious people, institutions and organizations accessing this data) (Cobianchi et al., 2022; Guni et al., 2024; Hindocha et al., 2022; Tarcan et al., 2024; Zhang et al., 2023).

The most important disadvantages of AI applications are program incompatibility, technological dependency, unemployment problem, creativity being limited to the creativity of the programmer (Khanzode & Sarode, 2020), AI can only perform the programmed tasks, it causes wrong results when it encounters non-routine situations, problems develop and the system tends to collapse (Bhbosale et al., 2020). The use of AI technologies, which are perceived as a global threat to humanity, in fully digitalized diagnostic, therapeutic and surgical applications, replaces the workforce, causing people to experience job anxiety, as well as musculoskeletal, neurological and psychological disorders in individuals who are less physically and mentally working and active (Tarcan et al., 2024).

In addition to these, when there are negative consequences related to the mechanical structure, faulty operation or use of robots with artificial intelligence, it will be impossible for them to take responsibility, so imposing legal and criminal liability on people such as institutions and manufacturers, programmers/technicians regarding an incident caused by a robot will create confusion, and in such cases, there will be a lack of accountability (Guni et al., 2024; Kandemir et al., 2023). In addition, it is stated that AI may threaten autonomy in the process of informed consent in terms of ethics, may cause unsafe results by causing errors in the principle of non-harm, may create differences between race, gender and social security types in the principle of justice, and may carry risks in terms of data privacy and confidentiality (Braun et al., 2020; Chen et al., 2019; Grote & Berens, 2020; Liyanage et al., 2019; Mc Cradden et al., 2020; Petkus et al., 2020). Therefore, it is crucial that AI technologies are developed in accordance with ethical and legal frameworks through the careful multidisciplinary work of engineers, researchers, surgeons, lawyers and bioethicists (Guni et al., 2024).

Reflections of Artificial Intelligence on Surgical Nursing

AI technologies have the ability to not only assess the patient, but to change everything in the area of focus. AI can predict which patient might be a better transplant candidate (Briceño et al., 2022), and in terms of care, it can help determine how best to assign operating room work patterns for higher efficiency in operating rooms (Yesantharao et al., 2020), how to better predict the availability of beds in clinics and the turnover rate of rooms in terms of efficiency (Lobo et al., 2023), and how to make the best staff planning (Hamilton, 2024; Stonko et al., 2018).

Care Services and Workforce Planning: With the widespread use of Da Vinci robotic technologies, one of the AI technologies, surgical nurses have been assigned a number of new roles, especially in the management of preoperative, perioperative and postoperative periods. Of course, these tasks include introducing the systems to be used during robotic surgery, cleaning and sterilization of robotic instruments, installation of equipment, patient preparation and positioning,

Hemşirelik Bilimi Dergisi
2025, 8(3), 413-427
Doi: 10.54189/hbd.1606325

placement and separation of robotic arms, connection of the display unit, and management of emergency procedures (Öztepe Yeşilyurt, 2023a). In addition, in telesurgery applications, which is still a very new application area with the accompaniment of 5G technologies to robotic surgery, nurses as a member of the surgical team are given important responsibilities such as collecting data, maintaining care, analyzing results, identifying safety issues, controlling robotic tools, cleaning and preparing equipment, separating the robot from the patient and creating charts (Neville, 2018; Yavuz Karamanoğlu, 2022).

Education: Considering the use of 3D printer materials in the field of nursing, it is stated in the studies that these materials are generally used in anatomy education of nurses and for simulation purposes, that anatomical complexity and physiopathologies are more easily understood with these materials, and that students will have positive effects in terms of becoming better equipped and gaining skills (Biglino et al., 2017; Lioce et al., 2020). In addition, it is stated that these materials can improve students' sense of touch and vision, thus increasing their active participation in learning (Sezer & Şahin, 2016; Lioce et al., 2020; Öztepe Yeşilyurt, 2023b), develop their imagination by transforming their own thoughts into concrete physical models, and realize complete and permanent learning more easily by concretizing the abstract information learned within the course (Kuzu Demir et al., 2016).

If we look at the effect of metaverse applications, another AI technology, on nursing, it is known that these applications are used for educational purposes in teaching complex skills such as visualizing the mechanical and physiological effects of nursing care (Gündoğdu & Dikmen, 2017; Yurttaş & Kabak Solak, 2023). It is stated that laboratory simulations, which enable the transfer of real life events to the student with three-dimensional virtual environment and interactive scenarios, make significant contributions to the student's active learning, making the information learned permanent, and developing procedural skills (Yurttaş & Kabak Solak, 2023). Metaverse applications enable the efficient use of time in education and the development and implementation of many low-cost scenarios (Butt et al., 2018; Chang et al., 2022).

It is stated that developments related to AI technologies in nursing care and practices are still limited (Gökçen Gökalp & Üzer, 2024). There is a need for research showing that 3D printer materials can be used more in the education of students in the field of surgical nursing. This technology needs to be developed and popularized in surgical nursing as in every field (Öztepe Yeşilyurt, 2023b). In addition, in studies conducted to evaluate the knowledge levels of nurses and nursing students regarding robotic surgery technologies, the use of which has become widespread in recent years, it is stated that their knowledge levels are partially sufficient (Okgün Alcan et al., 2019; Yeşilyurt & Durmaz, 2023), even 67.5% of the participants have no knowledge (Ak et al., 2017), but they should have sufficient knowledge and equipment (Ak et al., 2017; Okgun Alcan et al., 2019; Yeşilyurt & Durmaz, 2023). In this direction, providing robotic surgery trainings to surgical nurses and practicing them is very important in terms of increasing the effectiveness of surgical applications (Kang et al., 2016; Öztepe Yeşilyurt, 2023a; Uslu et al., 2019). In metaverse studies, the virtual reality application used as a method of gaining intravenous skills for nursing students is effective in students' skill acquisition (Günay İsmailoğlu & Zaybak, 2018; Jung et al., 2012), in virtual game-based safe blood transfusion training, these applications have a significant effect on nursing students' understanding of the blood transfusion process (Tan et al., 2017), and in another study conducted with a virtual game for cardiopulmonry resuscitation application, it was observed that nursing students' clinical and problem-solving skills improved and their motivation increased (Boada et al., 2015). The fact that these applications are only used for training purposes in simulation laboratories in terms of nursing constitutes the limitation in this field.

Ethical Issues: In addition to all these, there is another problem that affects nursing, and in a study, it was found that the robots developed increased nurses' concerns about unemployment due to their ability to develop interpersonal communication

Hemşirelik Bilimi Dergisi
2025, 8(3), 413-427
Doi: 10.54189/hbd.1606325

skills (Gökçen Gökalp & Üzer, 2024). It is also stated that AI technologies and robots will become more intelligent after each update by copying themselves (Tanioka et al, 2017). However, it is also stated that AI technologies, which have some shortcomings in ethical aspects and in practice, can reduce the workload on nurses by undertaking procedures that cause extra labor and time loss, which cause extra responsibility on nurses (paperwork, registration procedures, etc.) other than the main task of nurses, which is to provide care services (Gökçen Gökalp & Üzer, 2024).

In addition, in order for healthcare professionals to transition smoothly to these new technologies, ethical guidelines need to be organized in a way that provides up-to-date and continuous training opportunities (Elendu et al., 2023; Price & Cohen, 2019). However, healthcare professionals also have ethical responsibilities to understand and use these systems appropriately, ensure patient safety, and be alert to system errors (Akıncı & Antonoli, 2020). In addition, these technologies can increase diagnostic accuracy, organize workflows and improve patient care (Elendu et al., 2023). However, in this process, health professionals need to be effectively trained on these new technologies to adapt to new roles (Öztepe Yeşilyurt et al., 2024).

It is obvious that AI technologies have disadvantages and shortcomings as well as advantages. Although the use of AI technologies in the surgical field has positive effects, when evaluated from an ethical point of view, for example, it is necessary to reliably distinguish whether the negative consequences caused by robotic surgical applications are due to a malfunction in the system, a manufacturer's error or the surgeon's misuse. However, due to the lack of ethical standards in these applications, it is still unclear to whom the responsibility will belong in legal processes arising from faulty applications (Pai et al., 2023; Öztepe Yeşilyurt et al., 2024). In the legal regulations in this direction, the responsibilities of AI and robotic technological system manufacturers should be clearly defined and regulations should be issued to ensure that manufacturers take legal responsibility in situations that threaten patient safety, for example, in cases of complications arising from device malfunctions (Öztepe Yeşilyurt et al., 2024). Therefore, each country should make legal regulations in accordance with its existing laws, taking into account its own legal principles and social structure (Pai et al., 2023). In addition, in order to ensure patient safety in robotic surgery applications, continuing education programmes for healthcare professionals can be organised and national accreditation programmes can be developed.

In conclusion, it is seen that the number of studies examining ethics in AI technologies is quite limited and there is a great need for field studies on this subject. Since ethical evaluations in robotic surgery applications are generally included in the literature, it is recommended that healthcare professionals and surgeons who will perform the application in robotic surgery applications should act in ethical dimensions by carefully and carefully evaluating the potential risks (Öztepe Yeşilyurt et al., 2024).

CONCLUSION

This review examines all aspects of AI technologies from a surgical perspective, examining the innovations and limitations it provides to the field from different angles. It is clear that AI can make significant contributions to surgical treatment, surgical nursing and patient care. It is predicted that these highly innovative developments in the field of surgery may be used primarily in the future in battlefields, disaster areas, under the sea, space travel and even extraterrestrial colonization.

Although AI technologies, which are advancing rapidly day by day, have limitations, it is invaluable that they have tremendous effects in the field of surgical nursing in terms of improving and transforming all aspects of surgical patient care and contributing to surgical nurses in terms of education. However, considering that AI technologies will be a different door

Hemşirelik Bilimi Dergisi
2025, 8(3), 413-427
Doi: 10.54189/hbd.1606325

to the future, it will be very important that these technologies are carefully developed within ethically sound and legal frameworks by teams of surgeons, engineers, researchers, bioethicists and lawyers who are experts in this field.

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