Artificial intelligence in surgical education and training: opportunities, challenges, and ethical considerations – correspondence

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Dear Editor,

Artificial intelligence (AI) is increasingly being used in various fields, including surgical education and training. AI can provide a safe and controlled environment for trainees to practice surgical skills and can analyze large datasets of surgical procedures to identify areas for improvement[1–3]. However, as with any technology, there are ethical considerations that need to be taken into account when integrating AI into surgical education and training. This manuscript aims to explore the opportunities, challenges, and ethical issues associated with the use of AI in surgery education.

AI can enhance surgical education and training in several ways. One of the most significant benefits of AI is that it can provide a virtual training environment that simulates real surgical scenarios[2,4]. Virtual reality (VR) and augmented reality (AR) technologies can be used to create simulated surgeries that allow trainees to gain hands-on experience without the risks associated with real-life procedures.

Opportunities

(1) *Personalized learning*: AI can be used to create personalized learning experiences for surgical trainees. The technology can assess a trainee's strengths and weaknesses and provide targeted training modules to improve specific skills. This approach could potentially reduce training time and improve the efficiency of surgical education.

(2) *Simulation-based training*: AI can be used to create realistic surgical simulations that mimic real-world scenarios. Trainees can practice surgical procedures in a virtual environment, allowing them to gain experience without putting patients at risk. This approach can also help to reduce the cost associated with surgical training.

(3) *Predictive modeling*: AI can be used to create predictive models that can be used to identify surgical complications before they occur. This technology can help surgeons to take preventative measures and reduce the risk of complications during surgery.

(4) *Augmented reality*: AI can be used to develop augmented reality tools that can provide surgeons with real-time information during surgery. This technology can help surgeons to make more accurate decisions and improve patient outcomes.

(5) *Remote training*: AI can be used to provide remote training to surgical trainees. This technology can help to overcome geographical barriers and provide access to surgical training to individuals in remote locations.

Despite the numerous opportunities, there are also several challenges associated with integrating AI into surgical education and training. One of the most significant challenges is the lack of standardization in surgical procedures. Surgical procedures can vary significantly from one surgeon to another, making it challenging to develop standardized training programs. To overcome this challenge, AI algorithms will need to be trained on large datasets of surgical procedures to identify the most effective surgical techniques.

(1) *Data privacy and security*: The use of AI in surgical education and training requires the collection and storage of large amounts of sensitive data. There is a risk of this data being misused or stolen, which could have serious implications for patient privacy and security.

(2) *Bias and discrimination*: AI algorithms can be biased, and this can lead to discrimination in surgical education and training. It is essential to ensure that AI algorithms are developed and used in a way that is fair and unbiased.

(3) *Lack of regulatory framework*: There is currently a lack of regulatory framework around the use of AI in surgical education and training. This can make it difficult to ensure that the technology is used in an ethical and responsible manner.

(4) *Overreliance on technology*: There is a risk that surgical trainees may become over-reliant on AI technology, and this could lead to a reduction in the development of their surgical skills.

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(5) *Cost*: The development and implementation of AI technology can be expensive. This cost may be a barrier to the widespread adoption of AI in surgical research and education.

Ethical considerations

One of the most critical ethical considerations in AI is transparency and explainability. It is essential to understand how AI algorithms work and to be able to explain their decisions. This is particularly important in areas such as surgical education and research, where AI algorithms are used to make decisions that can have a significant impact on patient outcomes[5–7]. Some essential aspects of ethical issues are discussed below:

(1) *Informed consent*: One of the most important ethical considerations is informed consent. Informed consent is a fundamental principle in medical ethics that requires patients to be fully informed about their medical treatment before giving their consent. With the use of AI in surgical education and training, patients' data may be used to develop AI algorithms. Therefore, it is essential to obtain informed consent from patients before their data is used in this way.

(2) *Privacy and confidentiality*: Another important ethical consideration is privacy and confidentiality. Patient data is highly sensitive, and it is crucial to protect patients' privacy when using their data in AI algorithms. This requires developing appropriate security measures to ensure that patient data is not misused, hacked, or leaked. Confidentiality of data is also important in protecting the patient's rights, such that any sharing of patient data should be conducted in compliance with the privacy and data protection regulations.

(3) *Bias*: AI algorithms are trained on large datasets of surgical procedures, and the quality of the data is essential in determining the effectiveness of the algorithm. However, there is a risk of bias in the data used to train AI algorithms. This bias could come from the type of surgeries that are being analyzed, the demographic of the patients, or even the surgeon's experience. Therefore, it is important to carefully consider the dataset used to train the AI algorithms and to take steps to avoid or correct any bias that may be present.

(4) *Standardization*: The use of AI in surgical education and training requires standardized surgical procedures. Without standardization, it is difficult to develop AI algorithms that can accurately analyze surgical performance. The lack of standardization could lead to AI algorithms that are not effective in identifying areas for improvement or that provide inaccurate feedback to trainees. Therefore, it is important to develop standardized surgical procedures that are followed by all surgeons to ensure that the AI algorithms are accurate and effective.

(5) *Responsibility*: Finally, there is a question of responsibility when using AI in surgical education and training. Who is responsible for the accuracy and safety of the AI algorithms? Who is responsible if something goes wrong during a simulated surgery? These questions need to be addressed before AI can be fully integrated into surgical training.

AI has the potential to revolutionize surgical education and training, providing trainees with a safe and effective way to gain hands-on experience. However, there are several challenges that need to be addressed before AI can be fully integrated into surgical education and training programs. To overcome these challenges, it is essential to develop standardized surgical procedures, establish guidelines for patient privacy and consent, and develop AI algorithms that can adapt to the individual needs of each trainee. With the right approach, AI can transform surgical education and training, leading to better patient outcomes and improved surgical performance.

Ethical approval

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There are no conflicts of interest.

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Data availability statement

All data are included in the manuscript.

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