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its role in neurosurgery

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ABSTRACT

To acquire a wide range of technical skills, neurosurgeons undergo extensive and drawn-out training. Additionally, neurosurgery necessitates a significant amount of preoperative, intraoperative, and postoperative clinical data collection, decision-making, care, and recovery. The significance of artificial intelligence in neurosurgery has significantly increased during the past ten years. The potential of artificial intelligence to improve diagnostic and prognostic outcomes in neurosurgery is quite promising. It is important to clinical therapy because it helps neurosurgeons make crucial decisions during surgical interventions to improve patient outcomes and it enhances their abilities to give patients the finest interventional and non-interventional care possible. Furthermore, the acquisition, processing, and storage of clinical and experimental data are all greatly influenced by artificial intelligence. Its application in neurosurgery can lower surgical care expenses and offer top-notch medical treatment to a larger population. This article examines the use of artificial intelligence in preoperative, intraoperative, and postoperative care for both interventional and non-interventional aspects of neurosurgery, including diagnosis, clinical decision-making, surgical operation, prognosis, data collection, and research in the field.

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INTRODUCTION

In the context of medicine, "artificial intelligence" (AI) literally refers to "a robotic doctor" and can be understood as "a machine capable of thinking." Neuroscience is still far from comprehending human intelligence, and AI technology is still far from constructing an "artificial brain." Currently, "artificial intelligence" methods use wholly new technologies to solve very conventional and logistical problems.[1]

The field of neurosurgery is grueling work. Neurosurgeons must have significant training, endurance, physical dexterity, outstanding hand-eye coordination, the ability to make wise decisions, leadership and organisational abilities, compassion, communication skills, and the ability to operate in a team.[2] In 1988, Kwoh and colleagues performed the first robotic brain surgery that was guided by computerised tomography.[3] The gap between people and machines has been closed by recent technological advancements, allowing computers to replicate and even surpass natural human ability to produce so-called "artificial intelligence."[4]

AI technologies may make it possible to quickly and thoroughly analyse the vast amounts of clinical data produced in contemporary healthcare settings at a level that is otherwise not attainable for humans. By pushing the boundaries of clinical diagnosis, clinical decision-making, and prognostication, AI may subsequently improve clinical practice. Moreover, AI may enter the operating theatre and provide more accurate procedures with fewer errors if integrated with surgical robotics and other surgical adjuncts like image guidance. There has been little published about potential drawbacks to increased clinical automation, despite the great hoopla surrounding the imminent medical AI revolution. Both direct and indirect effects could be among them. Directly, flawed, insufficiently taught, or poorly comprehended algorithms may yield false results, which may have a significant effect. A clinical workflow that is increasingly automated may unintentionally worsen the deskilling of human doctors due to over-reliance, inadequate understanding, overconfidence, and a lack of necessary monitoring.[5]

In comparison to people, machines, algorithms, and AI have a higher level of safety since they can work continuously without experiencing physical or mental exhaustion. Additionally, machines are better able to learn and recognise patterns that are not immediately apparent to humans[6], revealing difficult-to-discern linkages[7]. AI can help neurosurgeons by decreasing surgical mistake rates, cutting expenses for prognosis, diagnosis, and treatment, increasing access to high-quality healthcare, and giving patients more control over their own decision-making processes.

Discussion

Artificial intelligence and neurosurgery

The clinical speciality of neurosurgery generates a lot of data due to the routine usage of cutting-edge medical technologies and medical information systems. These elements make the application of AI technology in the field of neurosurgery more likely to succeed. To design an AI-based project in neurosurgery, it is necessary to first analyse the present demand for and implementation of these technologies, as well as to identify research areas that have the potential to benefit from AI.[8]

Neurosurgery could be transformed by AI, machine learning (ML), and deep learning (DL). While ML, a subfield of AI, integrates computer science and statistics to enable computers to discover patterns through direct studying of data via experience, independent of external programming, AI tries to imitate the behaviour of intelligent individuals in computers.[9,10] AI has the potential to increase the precision of neurosurgery diagnosis and treatment, as well as give neurosurgeons fast access to useful and efficient tools for preoperative, intraoperative, and postoperative care. AI is able to identify tiny abnormalities and deformities in clinical data and neuroradiological images that are invisible to human sight. A subtype of machine learning called DL is built on neural networks, which has numerous layers of learning algorithms.[11] By giving recommendations to foster consensus among neurosurgeons on surgical approaches, AI can lower variances in patient outcomes while also improving prognosis and cutting expenses.

Role of AI in preoperative, intraoperative and postoperative phases of neurosurgery

AI can support surgeons in the preoperative stage of neurosurgery by helping to diagnose the condition, choosing patients for the best course of treatment, and guiding patients in making the best choices.[10] AI can improve surgeon performance and lower neurosurgery-related errors during the intraoperative stage of the procedure. AI in postoperative care can forecast outcomes, spot potential issues after surgery, and monitor data for better recovery and aftercare.

Role of AI to push the boundaries of neurosurgical research

AI and artificial neural networks can be helpful tools for understanding how intricate the nervous system is. Over the past ten years, increased data processing capacity and data accumulation have improved AI's performance in surgical research. Combining brain-computer interface (BCI) and AI can enable the creation of future robots and help paralysed individuals regain some of their sensory and movement abilities.[12]

A major drawback of AI-assisted research in neurosurgery is a small sample size when compared to the huge data that machine learning has processed in other fields of science and industry. It is

crucial to follow the guidelines of evidence-based medicine when organising research that makes use of AI technology, since these guidelines ensure the accuracy of the results and, as a result, boost their value for patients.

Challenges associated with use of AI in neurosurgery

Neurosurgical use of AI is not entirely risk-free. When AI is used too heavily in neurosurgery, there may be both direct and indirect harmful effects. At the most basic level, hardware and software issues can result in blunders during surgical procedures as well as incorrect interpretations of clinical data, lab results, and image scans that result in incorrect diagnoses.[5] At the secondary level, a surgeon may become discouraged from gaining the skills necessary to master surgical techniques if they rely too heavily on AI for surgical interventions. It can be dangerous to rely too much on algorithms to diagnose and treat disorders of the neurological system.[4]

The idea that AI will replace professionals in the medical field has been one of the concerns surrounding its adoption. It is crucial to keep in mind that the patient is at the centre of medicine, and the benefit to the patient should be the main factor in determining whether AI can benefit medicine or not. AI shouldn't replace humans, but rather should collaborate with them to complement their abilities and enhance their performance in order to deliver the best care possible.[4]

The cost of using AI in neurosurgery is another issue. The long-term advantages of lessening surgeons' effort, enhancing data management, and decreasing mistake, however, can offset the initial expense of AI training and operation.[4] In order to uphold ethical standards, the introduction of AI in neurosurgery needs to be carefully regulated and monitored.[13] To prepare the next generation of surgeons with cutting-edge technology, AI should be used in medical and surgical training as early as possible even at undergraduate level.[4]

Conclusions

To provide patients with the best results possible, neurosurgery can use AI to its advantage. AI has the potential to improve surgeons' preoperative, intraoperative, and postoperative skill sets in neurosurgery. Humans and machines can collaborate to improve healthcare delivery quality by acquiring, processing, and interpreting images, selecting patients for the most appropriate surgeries, improving intraoperative work, postoperative follow-up, and facilitating access to high-quality healthcare. Future widespread adoption of AI in neurosurgery will necessitate further study, funding, and multidisciplinary cooperation.

List of Abbreviations
AI: Artificial intelligence
ML: Machine learning
DL: Deep learning
BCI: Brain-computer interface

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