ORIGINAL ARTICLE

ChatGPT's contributions to the evolution of neurosurgical practice and education: a systematic review of benefits, concerns and limitations

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ABSTRACT

Aim This study provides a comprehensive review of the current literature on the use of ChatGPT, a generative Artificial Intelligence (AI) tool, in neurosurgery. The study examines potential benefits and limitations of ChatGPT in neurosurgical practice and education.

Methods The study involved a systematic review of the current literature on the use of AI in neurosurgery, with a focus on ChatGPT. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines were followed to ensure a comprehensive and transparent review process. Thirteen studies met the inclusion criteria and were included in the final analysis. The data extracted from the included studies were analysed and synthesized to provide an overview of the current state of research on the use of ChatGPT in neurosurgery.

Results The ChatGPT showed a potential to complement and enhance neurosurgical practice. However, there are risks and limitations associated with its use, including question format limitations, validation challenges, and algorithmic bias. The study highlights the importance of validating machine-generated content for accuracy and addressing ethical concerns associated with AI technologies. The study also identifies potential benefits of ChatGPT, such as providing personalized treatment plans, supporting surgical planning and navigation, and enhancing large data processing efficiency and accuracy.

Conclusion The integration of AI technologies into neurosurgery should be approached with caution and careful consideration of ethical and validation issues. Continued research and development of AI tools in neurosurgery can help us further understand their potential benefits and limitations.

Key words: artificial intelligence, ethics, machine learning, decision support systems

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Original submission:
29 September 2023;
Revised submission:
12 October 2023;
Accepted:
14 October 2023
doi: 10.17392/1661-23

Med Glas (Zenica) 2024; 21(1):126-131

INTRODUCTION

Artificial intelligence (AI) has emerged as a powerful tool in healthcare and medical research (1-3). The multidisciplinary approach of computer science and linguistics aims to create machines capable of performing tasks that normally require human intelligence (4, 5). The development of AI can be traced back to the mid-XX century, followed by the development of machine learning algorithms and other advanced techniques (6). With its ability to process vast amounts of data and identify patterns, AI has the potential to transform the way we approach healthcare and medical research (7). AI-based tools can help identify potential research topics, predict disease outbreaks, and assist in clinical and laboratory diagnosis (8). These tools can assist medical professionals in diagnosis, treatment, and research (8, 9). However, the use of AI in healthcare also raises ethical concerns related to privacy, data security, and accountability (8). Therefore, it is crucial to understand the advantages and limitations of AI-based tools in healthcare and medical research.

One of the recent AI tools that have gained attention in the medical field is ChatGPT. ChatGPT is an advanced language model developed by OpenAI that leverages deep learning techniques to produce human-like responses to natural language inputs (9). The model is trained on massive text datasets in multiple languages and can generate contextually relevant responses across a broad spectrum of prompts. Potential applications of ChatGPT in the medical field are vast. It can help medical professionals in diagnosing diseases, recommending treatment options, and predicting outcomes (10). ChatGPT can also assist in medical education by generating relevant and informative responses to students' queries. ChatGPT has shown promising results in various medical fields, including neurosurgery (10-12). The model's ability to generate human-like responses to natural language inputs can assist medical professionals in their decision-making process (11). However, the use of ChatGPT in medical practice also raises ethical concerns related to accountability and transparency (12). Therefore, it is crucial to analyse recent studies on ChatGPT's use in healthcare and medical research.

The aim of this study was to present a systematic review of recent studies on advancing neurosurgical practice and education with ChatGPT. This review will analyse and present the advantages, limitations, ethical considerations, future prospects, and practical applications of ChatGPT and AI in the healthcare and medical domains. The findings of this review can contribute to the ongoing discussions on the future of healthcare and medical research.

MATERIALS AND METHODS

Materials and study design

In line with the methodological framework prescribed by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines, this systematic review follows a structured approach (13).

In order to establish a comprehensive and well-defined search strategy, the expertise of a qualified medical librarian was sought, and the search was executed on the 12th of August, 2023. The search strategy was crafted using the keywords (ChatGPT OR OpenAI) AND (neurosurgery OR spinal surgery), effectively casting a wide net to ensure inclusivity. As a result of this thorough search, a total of 129 relevant records were identified, originating from three distinguished and reliable databases: PubMed (n=36), Scopus (n=46), and Embase (n=47) (Figure 1).

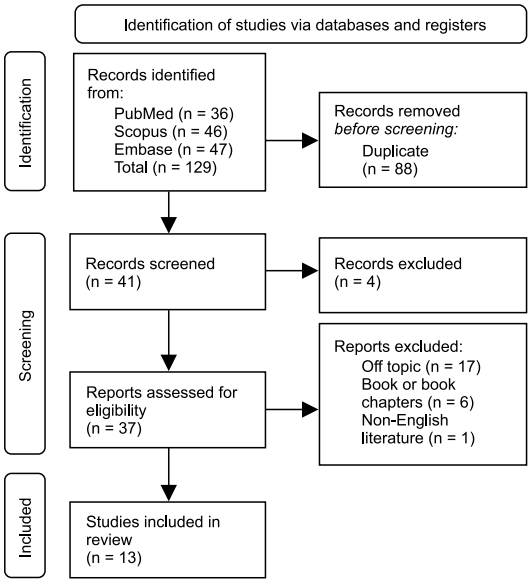

Figure 1. PRISMA flow chart

This review encompasses studies that specifically delve into the practical application of tools based on ChatGPT or OpenAI within the domain of neurosurgical practice and education. The studies considered peer-reviewed and exhibit a clear

articulation of the tangible benefits derived from the utilization of ChatGPT tools in the context of neurosurgical practice. Furthermore, a critical exploration of the associated risks, concerns, and limitations of employing ChatGPT in this field was deemed imperative.

The exclusion criteria were meticulously formulated to ensure the integrity and focus of the review: non-English records were excluded, as were the studies that explored the applications of ChatGPT or OpenAI in areas beyond the realm of neurosurgery or spinal surgery. A detailed breakdown of excluded studies reveals that 17 were deemed off-topic, 6 were identified as books or book chapters, and 1 study was composed in a language other than English.

In pursuit of a comprehensive and systematic approach to data extraction, a standardized template was employed to capture essential information from each study. This information encompassed a diverse array of critical elements, including the study's designated design, year of publication, subject matter, quantifiable benefits realized, potential risks identified, prevailing concerns or limitations elucidated, and, finally, the salient conclusions drawn or recommended actions.

Statistical analysis

The statistical analysis entailed determining the frequency (N) and percentage values (%) of the extracted data.

RESULTS

This systematic review analysed 13 studies published in 2023 that investigated the use of ChatGPT in neurosurgery (14-26) (Table 1). The most common study design was comparative analysis, which was used in 4 (31%) studies. A range of subjects was covered, including neurosurgery oral board exam scenarios, two (15%),

Table 1. Systematic review data summary

Reference	Study design	Year	Subject	Benefits	Risks, concerns or limitations	Conclusions or suggested actions
Ali et al. (14)	Comparative analysis	2023	Neurosurgery oral board exam scenarios	Improved performance of GPT-4.0.	Question format limitations, variability in interpretation	Stay updated on AI tools, address limitations, integrate AI in education
D'Amico et al. (15)	Editorial	2023	Integration of chatbots in neurosurgery	Streamlined data collection, patient care	Misdiagnosis, privacy concerns, ethical considerations	Verify machine-generated content, integrate AI in healthcare and academia
Duey et al. (16)	Comparative analysis	2023	Thromboembolic prophylaxis in spine surgery	Reasonable accuracy, improved ChatGPT-4.0.	Reliance caution, ongoing validation, potential biases	Utilize ChatGPT as a supplement, validate and refine, caution in reliance
Haemmerli et al. (17)	Comparative analysis	2023	Treatment recommendations for glioma patients	Accurate identification, good recommendations	Precision limitations, ethical concerns	Supplementary tool in tumour board decisions, AI advancements, human-in-the-loop
He et al. (18)	Letter to editor	2023	Endoscopic spinal surgery for lumbar disc herniation	Surgical support, data analysis	Appropriate use, data security risks	Valuable tool with responsible use
Hegde et al. (19)	Case report	2023	Generating natural language text in academic writing	Prose-like answers, case report generation	Validation challenges, lack of specificity	Caution, supervised use, ensure factual accuracy
Kuang et al. (20)	Editorial	2023	Evaluation of ChatGPT in neurosurgery	Quick information, educational resource	Superficial responses, ethical/legal concerns	Complement medical professionals, verify responses, careful integration
Lawson et al. (21)	Letter to editor	2023	Integration of AI in spinal surgery	Improved decision support, data access	Algorithmic bias, limitations in dynamic situations	Address biases, acknowledge limitations, cost implications, promote equitable use
Mishra et al. (22)	Observational study	2023	Neurosurgical information via ChatGPT	Quick information access	Inaccuracy, lack of expertise, readability issues	Use cautiously, supplement with professional guidance, improve AI accuracy
Sevgi et al. (23)	Commentary – preliminary study	2023	Use of ChatGPT in neurosurgical education	Alternative education, ease of access	Reliability issues, credibility doubts	Caution, potential improvement, further evaluation before adoption
Singh et al. (24)	Narrative Review	2023	Implications of ChatGPT in neurosurgery	Education, clinical support, admin. assistance	Reliability, inaccuracies, ethical concerns	Potential in education and diagnostics, ongoing evaluation, caution
Zamarud et al. (25)	Case report	2023	Leiomyosarcoma metastasis, ChatGPT for writing	AI-assisted manuscript drafting	Limited database access, dependence on input	Demonstrates AI capabilities, need for development, AI integration in research
Zamrud et al. (26)	Case report	2023	ChatGPT-generated case reports on synovial sarcoma	Accurate case reports, research assistance	Lack of specialized database access, manual references	AI value in case report creation, integration for research enhancement

AI, artificial intelligence;

integration of AI in neurosurgery, two (15%), and evaluation of ChatGPT in neurosurgery, two (15%) studies. Other subjects included thromboembolic prophylaxis in spine surgery, treatment recommendations for glioma patients, endoscopic spinal surgery for lumbar disc herniation, generating natural language text in academic writing, and integration of AI in spinal surgery.

The most common benefit of using AI tools in neurosurgery was improved performance or accuracy, which was reported in four (31%) studies. Other benefits included streamlined data collection and patient care, one (8%), surgical support, one (8%), and quick access to information, one (8%) study. Prose-like answers and case report generation was reported in one (8%), educational resource, one (8%), and complementary tool for medical professionals in one (8%) study.

The most common risk, limitation or associated with the use of AI tools was ethical considerations, which were reported in eight (62%) studies. Other risks and limitations included question format limitations, validation challenges, algorithmic bias, and potential biases with two studies each (15%), respectively. Reliance caution, precision limitations, data security risks, limitations in dynamic situations, superficial responses, ethical/legal concerns, cost implications, and promotion of equitable use were reported in one study of each (8%).

DISCUSSION

The integration of AI tools in neurosurgery holds transformative potential for decision support, data accessibility, and education. However, there exist associated risks and limitations. This systematic review, encompassing 13 studies from 2023, offers a comprehensive insight into the benefits and constraints of AI tools in neurosurgery. The studies cover a range of topics, including neurosurgery oral board exams, AI integration, and ChatGPT evaluation. Most employed a comparative analysis study design, with some editorials and letters. AI tools show promise in enhancing decision support, data access, and education in neurosurgery. Yet, concerns persist regarding reliability, ethics, and bias.

Notably, studies highlight the improved performance of AI tools in specific neurosurgical contexts. For instance, GPT-4 outperforms GPT-3.5 and Google Bard in higher-order management cases and imaging questions (14). ChatGPT demonstrates accuracy in thromboembolic prophylaxis recommendations and tumour board decision-making (16,17). Additionally, chatbot technology streamlines data handling, patient education, appointment scheduling, and surgical planning (18). While AI tools offer educational potential, caution is advised (27,28).

It is crucial to acknowledge that AI chatbots operate on machine learning principles, necessitating continual database refinement (29). ChatGPT have also proven to be effective in medical documentation, reducing time and enhancing accuracy for clinicians (30). It demonstrates promise in generating patient clinic letters, radiology reports, medical notes, and discharge summaries, simplifying documentation and improving clinician efficiency (30-33).

However, there are associated risks. GPT-4 exhibits limitations in multiple-choice and imaging-related assessments (14). Addressing privacy, security risks, misdiagnosis, and ethical considerations is imperative for wide-scale chatbot adoption (15,17). Limitations in accuracy and specificity arise in academic writing and neurosurgery contexts (19, 20). AI tools should be supplementary in decision-making, and their integration must be approached with caution (35,36). Validation and refinement are ongoing necessities for ensuring accuracy and reliability (37). Ethical concerns, including algorithmic bias and access disparities, require meticulous consideration (38,39). The ethical implications of ChatGPT's utilization are a prominent concern, along with legal responsibilities, data privacy, licensing, and regulations (38,39). Various ethical paradigms, encompassing humanistic and algorithmic ethics, offer frameworks for conscientious AI tool deployment (40-42). Prudent integration of AI tools necessitates addressing ethical and validation challenges (43).

AI's impact in neurosurgery extends to surgical planning, navigation, and image analysis. It enables personalized treatment plans based on data analysis, reduces operative errors, and enhances data processing efficiency for improved diagnoses and therapies (44). Additionally, AI opens avenues for personalized medical education (45).

The future of AI in neurosurgery promises even greater potential. Generative AI like ChatGPT

can synthesize data for rare conditions across centres (46-48). Incorporating longitudinal patient data into predictive models enhances outcome prediction, surgical planning, and decision-making support (48). Large language models like GPT-4 facilitate user-friendly interaction for clinicians and patients, benefiting communication and patient education (49).

This systematic review is subject to certain limitations, notably the limited number of included studies and the diversity in their methodological approaches. Potential authorial bias within the encompassed studies is a potential limitation. To address discrepancies in future investigations, it is recommended to establish standardized methodologies and approaches when examining the utilization of AI chatbots in the domain of medical sciences.

In conclusion, our study provides evidence that the use of ChatGPT in neurosurgery has the potential to complement and enhance neurosurgical practice. However, there are risks and limitations associated with the use of ChatGPT, such as question format limitations, validation challenges, and algorithmic bias. To address these concerns, ethical guidelines should be implemented to ensure that AI tools like ChatGPT are used in a responsible and beneficial manner for society. Our findings suggest that continued research and development of AI tools in neurosurgery can help us further understand their potential benefits and limitations. Overall, the integration of AI technologies into neurosurgery should be approached with caution and careful consideration of ethical and validation issues.

FUNDING

No specific funding was received for this study.

TRANSPARENCY DECLARATIONS

Competing interest: None to declare.

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