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Review Article

Ethical Implications of Artificial Intelligence in Anesthesiology: A Scoping Review

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ABSTRACT

Background: Nowadays, Artificial Intelligence (AI), as one of the advanced and rapidly growing technologies, has had widespread effects on various aspects of human life. In the healthcare sector, the adoption of AI methodologies has gained significant momentum, particularly in enhancing patient care, with anesthesiology emerging as a field keenly embracing these technological advancements. The use of AI in anesthesia is accompanied by specific ethical and social issues that require careful examination and deep understanding. The objective of this scoping review was to compile existing literature about the ethical considerations surrounding the utilization of artificial intelligence (AI) in anesthesiology.

Methods: This scoping review was conducted within the first three months of 2024. The research question was, "What are the ethical issues in the application of AI in anesthesia?" Based on the research question, researchers initially extracted relevant keywords using Medical Subject Headings (MeSH) and independently conducted preliminary searches in databases including Scopus, Web of Science, PubMed, Cochrane, and Google Scholar. The study selection process was guided by predetermined inclusion and exclusion criteria. The inclusion criteria were studies relevant to the research question. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for scoping reviews (PRISMA-ScR) was utilized to report the research procedure.

Results: The search strategy yielded a total of 327 articles. Consequently, the full text of 4 studies was examined. Of these, two studies were not considered to be included in the research due to their lack of connection with the primary research question. In total, 2 studies (both in English) were included in this review. Both of these studies were cross-sectional studies that examined the opinions of anesthesiologists regarding the ethical implications of using artificial intelligence in anesthesia.

Conclusion: The ethical integration of AI into anesthesia holds promise for improving patient care outcomes while upholding principles of safety, fairness, and accountability. Additional training programs and updated protocols are necessary for

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ensuring data security, collection, and processing. Additionally, Appropriate legal regulations concerning data processing should be developed.

Introduction

Nowadays, artificial intelligence (AI), as one of the advanced and rapidly growing technologies, has had widespread effects on various aspects of human life [1]. One of the areas where AI has increasingly been applied is in anesthesia [2]. In the healthcare sector, the adoption of AI methodologies has gained significant momentum, particularly in enhancing patient care, with anesthesiology emerging as a field keenly embracing these technological advancements [3]. AI applications in anesthesia offer the potential to augment decision-making processes for anesthesiologists, thereby facilitating more efficient resolution of clinical challenges [4]. These applications encompass a range of functionalities, including residency training, image analysis, utilization of mechanical ventilation robots, management of analgesia, administration of local anesthetics, evaluation of anesthetic depth, implementation of automated weaning protocols, preoperative assessments, and monitoring of neuromuscular blockade recovery [5-8]. Additionally, AI demonstrates effectiveness in predicting outcomes such as post-spinal hypotension, bradycardia, nausea, and vomiting, as well as urinary retention following spinal procedures [9].

In addition to these benefits, the use of AI in anesthesia is accompanied by specific ethical and social issues that require careful examination and deep understanding. Numerous healthcare professionals express dissent regarding the integration of artificial intelligence (AI) within the realm of anesthesiology, citing concerns related to ethical considerations, job displacement, and professional autonomy [10-11]. There exists substantial apprehension within the healthcare community regarding the adoption of AI systems in the absence of thorough validation and transparency [12]. Moreover, apprehensions extend to the potential for skill degradation among practitioners [13]. Furthermore, skepticism persists regarding the potential perpetuation of incorrect assumptions and disparities in care, stemming from algorithms utilizing surrogate health measures to forecast future healthcare requirements [14]. In addition, the reliance on AI models on extensive patient data for training purposes raises concerns regarding patient privacy and data security [15]. While the use of artificial intelligence in diagnosing diseases and clinical conditions in anesthesia can lead to increased accuracy in diagnosis and prediction of complications, it may also result in greater reliance on technology and decreased accuracy of human operators, potentially leading to serious mistakes [16]. Furthermore, the utilization of patient data for training AI algorithms raises significant concerns about the preservation of privacy and confidentiality of medical information [17]. Therefore, providing options to protect sensitive patient information and ensuring responsible use of this data is imperative (18). Moreover, the use of AI technologies in anesthesia can exacerbate existing disparities in access to medical care. Particularly in regions with limited resources, this may pose a threat to medical justice and necessitate solutions to ensure equal and fair access to anesthesia care. Addressing these ethical concerns and implementing measures to safeguard patient privacy, ensure data security, and promote equitable access to anesthesia care is paramount in the responsible integration of artificial intelligence into the field of anesthesia [18-19].

The objective of this scoping review was to compile existing literature about ethical considerations surrounding the utilization of artificial intelligence (AI) in anesthesiology. Scoping reviews serve to delineate the breadth of available literature on a nascent topic, aiming to identify existing evidence to inform subsequent reviews and direct further research endeavors [20]. Given the limited published information on this topic, the selection of a scoping review method is deemed appropriate for this investigation. This scoping review is a suggested approach that can provide future research with the opportunity to delve into more precise questioning and determine the best path to achieve the desired answers. Therefore, this review can assist future research in focusing on identifying the necessary questions and guiding further research with greater precision in providing comprehensive and clear answers to the challenges present in the relevant field.

Methods

This scoping review was conducted within the first three months of 2024. Scoping review, as a relatively new approach to evidence synthesis, is aimed at integrating available evidence. Currently, there is limited guidance on decision-making between a systematic review and a scoping review in the evidence synthesis process, particularly when the literature fails to provide confirmation. Comprehensive criteria have yet to be established, and there are aspects perceived as significant, complex, or divergent, which hinder the execution of a more precise systematic review [21-24]. Despite the expedited process, we ensured systematic

rigor and maintained both integrity and methodological precision. Our approach was guided by Arksey and O'Malley's scoping review framework [25] and adhered to the PRISMA-ScR reporting standards [26]. We followed the five stages of a scoping review as outlined by Arksey and O'Malley [24-25, 27]:

- Stage 1 involved identifying the research aims and questions;
- Stage 2 focused on identifying relevant studies;
- Stage 3 was dedicated to study selection;
- Stage 4 entailed charting the data;
- Stage 5 encompassed collating, summarizing, and reporting the results.

Considering the recent emergence of artificial intelligence (AI) in the field of anesthesiology and the lack of comprehensive opinions regarding the ethical implications of its application in anesthesia, our research question is formulated as follows:

"What are the ethical issues in the application of AI in anesthesia?"

Search strategy

Based on the research question, researchers initially extracted relevant keywords using Medical Subject Headings (MeSH) and independently conducted preliminary searches in databases including Scopus, Web of Science, PubMed, Cochrane, and Google Scholar using the following keywords: "Ethical Issues," "Ethical Issue," "Issue, Ethical," "Issues, Ethical," "Moral Policy," "Moral Policies," "Policies, Moral," "Policy, Moral," "Ethics," "Ethical Problems," "Artificial Intelligence," "Machine Learning," "Anesthesia," "Anaesthesia," "Anaesthesiology," and "Anesthesiology."

All the articles from 1999 to 2024 were analyzed based on their titles and abstracts to eliminate irrelevant entries. Any discrepancies were resolved through discussion among six researchers, resulting in unanimous agreement on the selection of articles for inclusion in the study. Data were extracted from all studies, including authors, objectives, participants, interventions, outcomes, and findings.

Study Selection

The study selection process was guided by predetermined inclusion and exclusion criteria. The inclusion criteria were studies relevant to the research question, studies conducted in the English language, and studies focusing on the intersection of ethics in anesthesia and artificial intelligence. The exclusion criteria included systematic reviews, case reports, studies with unavailable full texts, animal studies, conference papers, book chapters, and editorials. Duplicate studies were removed, and all articles were downloaded into EndNote version 9 software for further analysis. Subsequently, five researchers evaluated the articles based on the inclusion and exclusion criteria. In case of any disagreements, the sixth member of the team made the final decision regarding the inclusion of articles. Data extraction was performed by five researchers. The extracted data from each article included the following: study details (primary author and publication year), study characteristics (objectives, country of study, and study population), population characteristics (average age, healthcare profession or patients, educational background), and assessment tools. Subsequently, the collected data were analyzed and prepared for presentation. Discrepancies in the studies were examined, and recommendations for future research were also discussed (Figure 1).

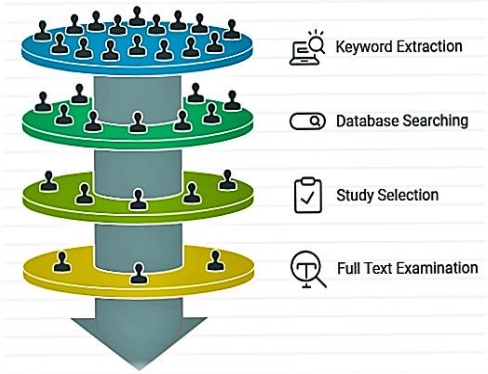

Figure 1- Summary of Methodology

Results

The search strategy yielded a total of 327 articles. Out of these, 140 were removed due to duplication. Additionally, 3 articles were excluded because they were conference papers; out of a total of 27 reviewed sources, 21 were systematic review sources and 6 were book chapters. Only 4 of their full-text studies were reviewed, 2 of which were excluded due to not being relevant to the research question. Finally, 2 studies, both in English, were included in the review. (Figure 2). Both of these studies were cross-sectional studies that examined the opinions of anesthesiologists regarding the ethical implications of using artificial intelligence in anesthesia. One study conducted in Germany on 21 and 49 anesthesiologists, respectively, utilized questionnaires and interviews to inquire about the opinions of anesthesiologists on this issue. The average age of the physicians was 33 years old, with 76% of them being female, and 81% were residents in anesthesia, with 4 attending anesthesiologists [12]. The second study, conducted in Turkey, involved 285 anesthesiologists with an average age of 42 years and an average work experience of 10.95 years to examine the ethics of using artificial intelligence in anesthesia under ultrasound

guidance. 50.5% of the respondents were male and 49.5% were female. 39.6% of these physicians had over 10 years of work experience, while the rest had less than 10 years of experience, and 74.7% of these physicians routinely used ultrasound in anesthesia. The opinions of these physicians were assessed using an 8-item questionnaire [18]. The detailed findings of the reviewed studies are presented in (Table 1).

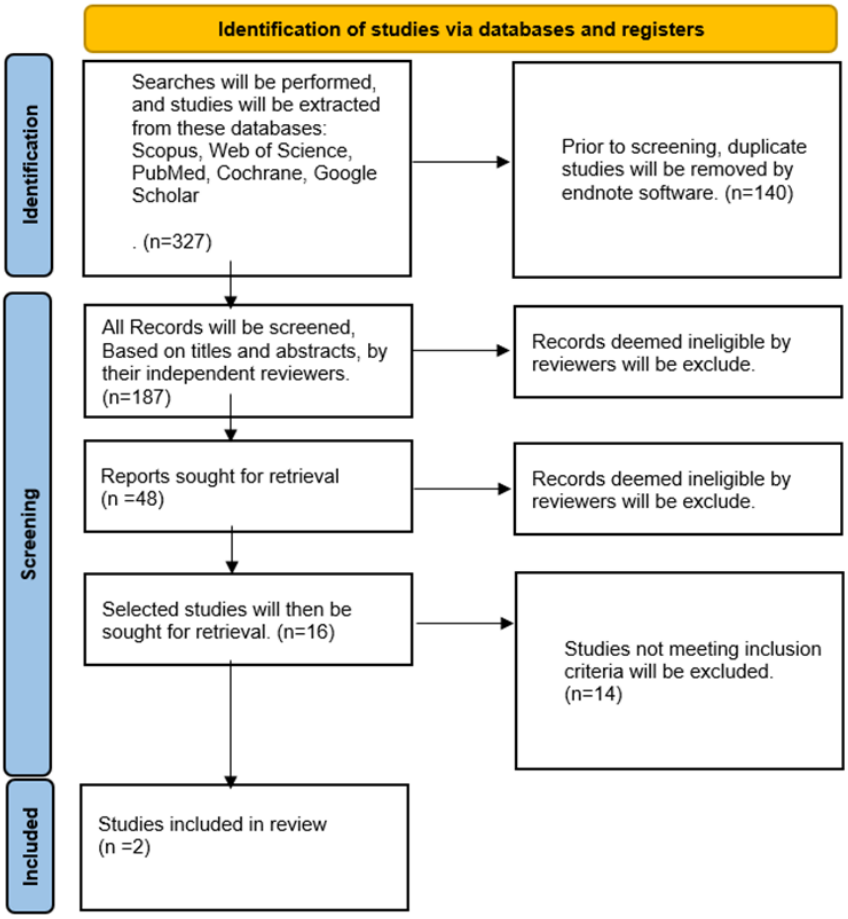

Figure 2- Diagram of study screening and selection

Table 1- An overview of scholarly research pertaining to the ethical considerations inherent in the application of artificial intelligence within the domain of anesthesiology.

Num	1	2
Year/Author	Henckert et al. 2023 [12]	D'Antonoli TA et al. 2023 [28]
Country	Germany	Turkey
Title	Attitudes of Anesthesiologists toward Artificial Intelligence in Anesthesia: AMulticenter, Mixed Qualitative–Quantitative Study	Anesthesiologists' Perspective on the Use of Artificial Intelligence in Ultrasound-guided Regional Anaesthesia in Terms of Medical Ethics and Medical Education: A Survey Study
Sample size/ population	The first, qualitative part of the study consisted of face-to-face, structured interviews with physician anesthesiologists (n = 21). The second part of the study was conducted using a questionnaire for ranking (n=49). The study participants were all practicing physician anesthesiologists.	Privacy and data governance are 2 potential ethical issues.
Ethical issues	The paper highlights concerns surrounding explainability and responsibility in AI systems. These issues have emerged as critical	The study indicates a high level of agreement (75%) on the acceptability of recording data anonymously and storing it in memory, while a

	considerations in the field of artificial intelligence in anesthesia.	minority (10%) view AI retention of patient data as a privacy concern. These results offer insights into the evolving discourse on data privacy and AI ethics in anesthesia.
Result	Three main themes from physician anesthesiologists' responses to a series of in depth interviews and a follow-up questionnaire obtained, including (1) a good pre-existing understanding of AI, (2) a balanced view of the pros and cons of AI as applied to anesthesia, and (3) a generally positive view of the use of AI to predict clinical events. dataset demonstrates a good level of pre-existing knowledge of AI in sample of practicing anesthesiologists. Notably, all participants were able to give a definition of AI.	Based on the analysis of survey responses, it was found that statistical significance was only determined in 3 judgments out of the factors considered, such as age, gender, time spent in the profession, routine USG use, and active participation in assistant training. Interestingly, 68.8% of participants who actively engaged in training residents believed that the use of AI in Regional Anesthesia (RA) would enhance the relationship between trainers and trainees, compared to 52.6% of those who did not participate in residency training. This difference was not statistically significant (P = 0.2). Additionally, when asked about the responsibility in case of complications during AI use, 26.8% of participants who regularly use USG in RA applications agreed that the practitioner would bear sole responsibility, while only 11.1% of non-USG users agreed. This difference was also not statistically significant (P = 0.2). It's interesting to see the varying perspectives on these topics among participants with different backgrounds and experiences.
Conclusion	In this study, it was found that anesthesiologists exhibit a high level of knowledge regarding artificial intelligence (AI) and maintain a nuanced perspective on the incorporation of AI within the field of anesthesia. The research suggests that anesthesiologists possess a comprehensive understanding of AI technologies and demonstrate a thoughtful approach towards the utilization of AI in anesthesia practice.	The majority of anesthesiologists believe that using artificial intelligence in regional anesthesia will decrease complications. Although ethical concerns about privacy and data governance were low but participants were concerned about "accountability for errors."

Discussion

The integration of artificial intelligence (AI) in anesthesia presents a myriad of challenges that must be carefully addressed to ensure patient safety and quality of care. One significant issue is the accountability for errors that may occur during the use of AI systems in anesthesia. As AI algorithms are inherently complex and may not always provide accurate or reliable results, it can be difficult to determine who is ultimately responsible for errors that occur during the decision-making process. This lack of clear accountability can lead to confusion and potential legal implications, highlighting the need for robust oversight and regulation in the use of AI in anesthesia. Furthermore, the limited applicability of AI in complex decision-making scenarios poses a significant challenge in the field of anesthesia. While AI systems may excel in certain tasks, such as data analysis and pattern recognition, they may struggle to navigate the nuanced and dynamic nature of anesthesia practice. These limitations can result in suboptimal decision-making and compromise patient outcomes, underscoring the importance of maintaining human oversight and expertise in anesthesia care. Additionally, the lack of transparency in AI algorithms and decision-making processes further exacerbates these challenges, raising concerns about the reliability and trustworthiness of AI systems in safeguarding patient privacy and preventing potential privacy violations [12, 18].

Yelne et al. take a broader perspective on the challenges of AI in nursing. They identify a range of ethical concerns, including the lack of transparency in AI algorithms, the potential for cyberattacks, patient awareness, data trustworthiness, and unclear responsibility for patient outcomes [29]. Their study highlights the importance of addressing ethical challenges to ensure the responsible and ethical use of AI in healthcare. Who would be held responsible if AI-related errors occur, particularly those that result in patient harm? This question becomes even more complex

in cases where multiple participants are involved, such as the algorithm developer, physician, and healthcare organization. Another shared concern is the need for transparency and trustworthiness in AI systems. Healthcare professionals need to understand how AI algorithms work and trust the data they use to make informed decisions about patient care. However, the lack of transparency and potential for bias in AI algorithms can undermine trust and confidence in AI-assisted healthcare.

Additionally, D'Antonoli et al.'s study highlights key ethical considerations in integrating artificial intelligence (AI) in radiology. They emphasize the importance of algorithm transparency, patient privacy, and ethical guidelines to ensure responsible AI implementation. Transparent algorithms enable clinicians to assess AI reliability, promoting trust and informed decision-making. Protecting patient data and obtaining informed consent are crucial for maintaining patient privacy. Clear ethical guidelines are essential for addressing issues like bias mitigation and accountability. By prioritizing transparency, privacy, and ethical guidelines, healthcare providers can leverage AI technology ethically in radiology practice while safeguarding patient welfare [28].

Furthermore, in a study conducted by Sharma et al., ethical considerations of AI usage in orthopedics have been discussed. Their study emphasizes the importance of data privacy and security measures in protecting patient confidentiality and maintaining public trust in fracture diagnosis. The study highlights the need for robust safeguards to ensure the safe and secure handling of patient data when using AI technologies in medical decision-making processes. They believed that ethical considerations are crucial for upholding patient rights and ensuring compliance with data protection regulations [30].

It is important to understand that the purpose of artificial intelligence systems in anesthesia is not to replace professional humans but to help and improve their abilities. While AI algorithms show impressive performance in certain aspects of anesthesia, they still rely on human expertise for validation and understanding. Working together, artificial intelligence systems and human experts can combine computing power with clinical knowledge to achieve better results in anesthesia [31]. Furthermore, anesthesiologists have a fiduciary duty to prioritize their patients' best interests and rely on various support systems, including researchers, scientists, and regulatory bodies, to ensure evidence-based clinical practices [32]. Currently, there is a lack of clear regulatory guidelines on anesthesiologists' responsibilities regarding the use of AI in clinical decision-making, leading them to rely on their judgment [18]. These challenges require collaboration among stakeholders to establish clear guidelines and regulations, ensure patient autonomy and privacy, and mitigate the risks of bias and discrimination [28]. Furthermore, ongoing research and development efforts should focus on enhancing data quality and transparency in AI systems while fostering a deeper understanding of the implications and limitations of AI in clinical practice [33]. Generally, the ethical integration of AI into anesthesia holds promise for improving patient care outcomes while upholding principles of safety, fairness, and accountability [34]. Additional training programs and updated protocols are necessary for ensuring data security, collection, and processing. Additionally, appropriate legal regulations concerning data processing should be developed [17].

Conclusion

In summary, the ethical use of AI in anesthesiology necessitates clear guidelines to protect patient privacy and ensure data security. Transparency, accountability, and bias mitigation are crucial for ethical AI integration. Collaborative partnerships between AI systems and anesthesiologists can enhance patient care outcomes [7, 12, 14, 18]. Stakeholders must prioritize patient welfare, address data quality issues, and establish robust ethical frameworks for responsible AI integration in anesthesiology. In the present scoping review, the lack of studies conducted in the field of AI and ethics in anesthesia may influence research evaluations. Further studies in this field in the future can be enlightening for us.

Abbreviations

AI: Artificial Intelligence
MeSH: Medical Subject Headings

Ethics approval and consent to participate

Not applicable.

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