

Artificial Intelligence: Predicting Perioperative Problems

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Abstract

The rapidly developing field of artificial intelligence (AI) may soon equip clinicians with algorithms that model and predict perioperative problems with extreme accuracy. Here, we outline emerging AI applications in preoperative risk stratification and intraoperative event prediction, where algorithm performance has been shown to outstrip commonly used conventional risk prediction tools. While offering an enticing view of a novel perioperative practice with superhuman foresight, AI's limited scope and lack of transparency remain key challenges for widespread adoption. As yet it is unclear whether machine learning alone can influence human clinical practice to exert real-world effects on patient outcomes.

Key words: anaesthesia; perioperative medicine; artificial intelligence; machine learning; data science; risk prediction

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Artificial Intelligence

Algorithms that mimic human cognitive tasks such as prediction, clustering, classification and decision-making are termed artificial intelligence (AI), which comprises several subgroups. 'Machine learning' (ML) refers to algorithms that learn patterns from data, rather than humans defining algorithmic rules by hand. This process can be supervised, where algorithms are trained on labelled data of a known outcome, or unsupervised, in which algorithms sort unlabelled data. 'Deep learning' (DL) is a branch of ML that utilises multilayered artificial neural networks to capture unseen features or complex relationships within raw, unstructured data.

Through digitisation of health records and physiological monitoring in the operating theatre, perioperative medicine is becoming data-rich, allowing AI to perform sophisticated predictive analyses on these growing datasets. In this article we consider the early clinical applications of AI in predicting specific adverse perioperative events, and consider the challenges of implementing these models into routine perioperative care.

Preoperative Risk Stratification

Established risk prediction tools use statistical methods to identify relationships between variables and develop a mathematical model that predicts perioperative morbidity and mortality based on patient risk factors. Machine learning

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models may apply similar techniques such as regression algorithms to accurately fit complex curves and generate predictions across far larger datastreams.

Validated AI models have been developed using data from hundreds of thousands of patients. In single-centre retrospective studies, several models demonstrate superior performance versus commonly used risk stratification tools. In recent years, there has been an explosion in models attempting to predict: 30-day mortality, length of stay in intensive care, neurological and cardiovascular complications, acute kidney injury (AKI), sepsis, venous thromboembolism, wound infections, pneumonia, delirium, risk of post-intubation hypotension and post-op nausea and vomiting (Van der Meijden et al, 2023; Yoon et al, 2022). One major challenge in the development of these models is their limited scope. Machine learning of this kind will only ever answer a narrowly focused question posed to it, simply performing the computation without any wider real-world context or the ability to think laterally where anomalies occur.

Intraoperative Event Prediction

The use of AI-guided prediction has also heralded a new generation of dynamic intraoperative indices, where data from physiological monitoring is integrated in real time.

Machine learning models analyse biosignals such as the arterial pulse waveform, electrocardiogram, capnography and plethysmograph to predict hypotension, hypoxia and AKI with impressive foresight. With these decision support systems, clinicians can be alerted to impending hypotension up to 15 minutes before the event occurs, hypoxia up to 5 minutes prior, and AKI 24 minutes before traditional criteria are met (Maheshwari et al, 2023). The ability of the future anaesthetist to avoid previously unforeseeable events could have major implications for postoperative morbidity, yet early studies examining the clinical benefit of these tools show mixed results as clinician discretion remains about whether to act (Van der Meijden et al, 2023).

Accidental awareness under anaesthesia is another such complication difficult to detect clinically. AI models are extremely well-suited to exploit the continuous variable data created by processed electroencephalogram (pEEG) monitoring to predict adequacy of anaesthesia. Indeed, AI has already been shown to outperform the commonly used bispectral index (BIS) and Entropy under certain conditions (Hashimoto et al, 2020). In this context AI could simplify the interpretation of disordered analogue pEEG data, freeing up cognitive bandwidth for clinicians in the operating theatre.

Future Directions

In combination with closed-loop feedback systems, AI-driven predictive analytics could soon lead to fully-automated delivery of anaesthesia, smoothly titrating anaesthetic depth and maintaining stable cardiorespiratory physiology. Yet to be accurate and reliable, AI requires high quality, objective data from diverse sources. Without this, the practices, biases and inequalities that already exist in perioperative

medicine are reinforced. For example, patient data used to train AI models must be highly representative to the population it is applied to. Moreover, the ‘black box’ of AI computation creates a lack of transparency in how machines derive their conclusions. Without providing ‘explainability’ of how machine reasoning occurs, trust in AI is harmed and clinicians may be left disempowered and sceptical of such results (Paiste et al, 2024).

Conclusion

AI is a nascent but growing industry that will likely lead to an increasingly automated surgical pathway, yet serious questions remain about how to integrate AI into clinical practice to complement rather than compete with healthcare providers. Taking a renewed, technologically-driven approach to surgery appeals to a vision of highly individualised patient-centred perioperative care, yet first and foremost AI proponents must present evidence of improved patient outcomes when supporting our current perioperative framework.

Availability of Data and Materials

Not applicable.

Author Contributions

Both authors fulfil the four authorship criteria of ICMJE guidelines. JH contributed to conception of article, research and literature review, drafting and amendments of initial manuscript, revisions to manuscript. JM contributed to conception of article, literature review, conceptual contributions to initial manuscript, revisions to manuscript. Both authors contributed to important editorial changes of important content in the manuscript. Both authors read and approved the final manuscript. Both authors have participated sufficiently in the work and agreed to be accountable for all aspects of the work.

Ethics Approval and Consent to Participate

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Conflict of Interest

The authors declare no conflict of interest.

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