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Surge of Artificial Intelligence: A Metamorphosis in the Pedagogical Landscape of Perioperative Medicine

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Abbreviations: AI: Artificial Intelligence; ML: Machine Learning; DL: Deep Learning; CNN: Convolutional Neural Network; OCT: Optimal Classification Tree; ANN: Artificial Neural Network; GA: General Anaesthesia; DSS: Decision Support Systems; CLADS: Closed Loop Anaesthesia Design Systems; REALITI: Robotic Endoscope Automated Via Laryngeal Imaging for Tracheal Intubation; EWS: Evita Weaning System; VR: Virtual Reality; AR: Augmented Reality.

Introduction

Anaesthesiology is well-positioned to benefit from advances in artificial intelligence (AI) as it touches on multiple elements of clinical care, including perioperative and intensive care, pain management, and drug delivery. Therefore integration of AI and its technological advancement will significantly impact the field of anaesthesia, and enhance patient care, safety, and efficiency (Figures 1 & 2).

Before dwelling on applications of AI, a diagrammatic representation of artificial intelligence (AI), Machine learning (ML), and Deep learning (DL) is depicted in figure 1 to understand the framework.

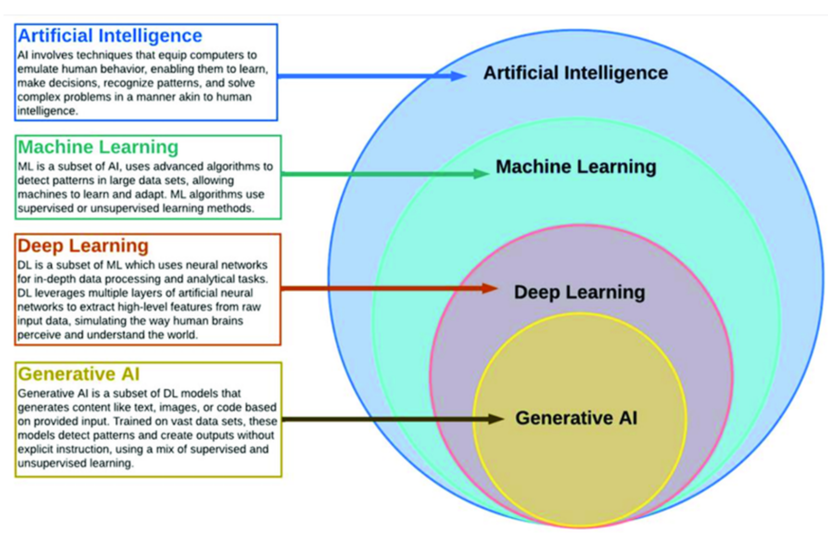

Figure 1: Depicts A Simple Representation of the Relationship between AI, ML, and DL.

Here are several ways in which AI is influencing anaesthesia:

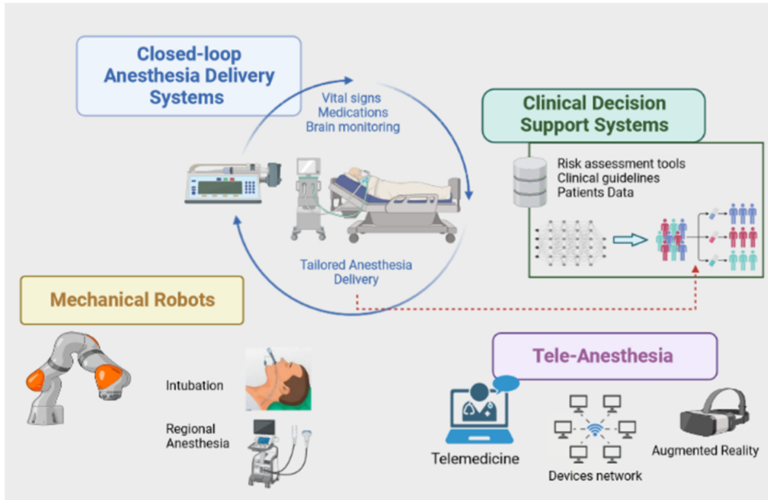

Figure 2: Info Graphic of Potential Modalities for AI-Based Applications in Anaesthesia.

Predictive Analytics

AI-powered predictive analytics can anticipate complications during anaesthesia administration, one such aspect is difficult airway prediction. Using a convolutional neural network (CNN) which is a subdomain of deep learning (DL), AI is explored to integrate subjective factors like facial appearance, speech features, habitus, and other poorly known features to predict the difficult airway [1].

By analysing patient data in real-time, machine learning (ML) algorithms can accurately predict the adverse outcomes following complex surgeries using the optimal classification tree (OCT) methodology [2]. Artificial neural network (ANN) have been tested to predict the return of consciousness following general anaesthesia (GA) [3], recovery of neuromuscular blockade [4], and prediction of hypotensive episodes following spinal anaesthesia [5]. This will prompt the healthcare providers to potential issues before they escalate, allowing for proactive intervention and better patient management.

Automated Monitoring & Decision Support Systems (DSS)

Perioperative monitoring is a tedious task, and alarm fatigue experienced by the anaesthesiologist can be a serious safety concern for the patients. AI-driven monitoring systems continuously assess patient vital signs during surgery, providing early detection of adverse events, and also reducing the lower false alarms thereby reducing operator fatigue.

Hypotension following GA is not uncommon and prolonged hypotension may lead to undesirable consequences. The Acumen HPI algorithm™ uses sophisticated machine learning to map various parameters to predict the hypotensive event well before and also guides as a decision-supportive system to use fluids, inotropes, or vasopressors in the appropriate clinical context [6].

Automated Intervention

The most intelligent and efficient use of automated monitoring is combining the various systems monitoring along with therapy to correct it to the pre-set value, by using a closed-loop feedback system. AI-controlled drug delivery systems precisely administer anaesthesia drugs based on patient response and physiological feedback. These closed-loop systems continuously monitor patient parameters and adjust drug dosages in real time, optimizing anaesthesia depth while minimizing the risk of overdose or underdose.

Closed Loop Anaesthesia Design Systems(CLADS): Researchers have been interested in controlling the depth of anaesthesia since the introduction of the Bickford apparatus in the 1950s, and later Mcsleepy to various closed-loop anaesthesia design systems(CLADS). When complexity arises these algorithms cannot match the humanistic skill of decision making poses a significant challenge in the real world since, these early systems use a top-down rule-based algorithm. Thanks to cognitive computing which uses a bottom-up design to train from the inputs and perform the task and desired responses, unlike a strict rule-based algorithm [7].

This advanced AI opens the possibility of a closed-loop system not only for the precise depth of anaesthesia control but also for blood glucose control [8], and fluid-administration system based on dynamic predictors of fluid responsiveness [9].

Automation in Airway: Although automation is changing the landscape of perioperative medicine anaesthesiologists, were in feigned peace that AI could not take away the prime skill of ventilation and Intubation until recently. The fusion of robotic technology and advanced AI put forward the development of the basic Kepler Intubation system into an advanced Robotic Endoscope Automated Via Laryngeal Imaging for Tracheal Intubation (REALITI) system which made the thought turnaround [10].

AI is also explored in Ultrasound and Echocardiography by Shaikh F, et al. [11] assisting the sonographer with completely automated measurements may improve the accuracy, and inter-observer variability, and also decrease the workload of the health care provider. Extending these automated technologies to remote settings where trained cardiologists in short benefit the rural people.

Postoperative Care

AI algorithms can analyse postoperative data to predict patient recovery trajectories and identify individuals at risk of complications such as pain, respiratory depression or circulatory failure. This enables healthcare providers to implement tailored postoperative care plans and interventions, ensuring smoother recovery and improved patient satisfaction. One such exploitation of AI is automated weaning using a fuzzy logic algorithm called Evita Weaning System (EWS) [12]. This EWS has made it feasible to remotely control the ventilator, thus weaning the patients from the controlled mode to assisted spontaneous breathing flawlessly.

Simulation and Training

The postgraduate training has shifted from the traditional method of a behaviouristic model to the constructive model, which adapts the learner-centric approach. The soul domain of competency-based medical education is acquiring procedural skills, and simulation is the key novel method for it. AI-powered simulation platforms like virtual reality (VR) and augmented reality (AR) offer immersive training environments for anaesthesia providers [13]. These simulations accurately replicate surgical scenarios, allowing anaesthesiologists to practice various techniques, refine their skills, and make critical decisions in a risk-free setting. This enhances competency and preparedness for real-life situations.

Research and Development

AI facilitates research in anaesthesia by analysing large datasets, identifying novel drug targets, and predicting treatment outcomes. Machine learning algorithms can uncover hidden patterns in medical data, leading to advancements in anaesthesia techniques, pharmacology, and perioperative care.

Conclusion

Overall, the integration of AI technologies in anaesthesia holds great promise for improving patient safety, optimizing anaesthesia management, and advancing the field through data-driven insights and innovation. However, continued research, validation, and collaboration between clinicians, researchers, and technology developers are essential to realizing the full potential of AI in anaesthesia practice.

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