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Artificial intelligence in anaesthesiology, intensive care, and pain medicine: opportunities for a digital future

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Artificial intelligence (AI) is a rapidly advancing field of computer science that enables machines to perform tasks traditionally requiring human cognitive abilities such as learning and problem solving.[1] It is commonly defined as a system's ability to accurately interpret external data, learn from such data, and apply that knowledge to achieve specific goals and tasks through adaptatve decision-making.[2] AI is increasingly embedded in daily life, shaping how people work, learn, and interact. In transportation, AI helps manage traffic flow, power navigation systems, and support the development of safer, more efficient vehicles. In finance, it improves security through fraud detection, streamlines transactions, and enables personalised financial services. Even in daily routines, smart devices and virtual assistants help manage schedules, control home environments, and provide instant access to information.

In healthcare, the potential of AI is vast, though widespread clinical adoption remains at an early stage. AI can enable healthcare systems to advance towards AI augmented care, encompassing precision diagnostics, precision therapeutics, and ultimately precision medicine.[1] It incorporates machine learning that includes deep learning and natural language processing to enhance data interpretation and decision-making.[3] Research in AI application continues to expand rapidly, demonstrating potential in drug discovery, virtual clinical consultation, disease diagnosis, prognosis, medication management, and health monitoring.[1,3] In the near future, AI tools may enable earlier detection of diseases and guide timely, targeted interven-

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tions. They could also support healthcare systems by improving workflow efficiency, resource allocation, and decision-making. Ultimately, AI offers promising opportunities to make healthcare delivery more proactive, precise, and patient-centred.

AI is also transforming the landscape of anaesthesiology and intensive care, which are uniquely positioned to benefit due to its data-rich, real-time environments. Predictive analytics, anaesthesia delivery systems, patient monitoring, image analysis, decision support systems, personalised anaesthesia, simulation-based education, and risk assessment tools present opportunities to refine how anaesthesiologists learn, make decisions, and deliver care.[4,5] In anaesthesia, AI can assist in predicting difficult airways, optimising anaesthetic dosing, enhancing intraoperative monitoring through continuous data interpretation, and predicting intraoperative hypotension and postoperative complications.[4,5] Moreover, AI-assisted devices have been shown to improve ultrasound image acquisition and interpretation for regional anaesthesia, potentially broadening access to this technology by enabling use even among non-experts.[3] Beyond direct clinical applications, AI can also enhance hospital logistics by accurately predicting surgery durations and potential cancellations, improving operating theatre efficiency, reducing waiting times, and lowering costs.[3]

In intensive care, AI systems may help identify patients at risk of sepsis, acute kidney injury, or mortality, while assisting with ventilator management, haemodynamic optimisation, and nutritional planning.[6] In pain medicine, AI holds the potential to personalise therapy by analysing individual characteristics and biosignals, such as electroencephalograms, electromyography, and facial recognition to quantify pain objectively and guide personalised analgesic titration and opioid stewardship.[7] Within medical education, AI-driven simulation, virtual patients, and adaptive learning platforms can revolutionise how trainees acquire and refine clinical skills. Although many of these innovations are still in developmental stages, growing evidence highlights AI's capacity to improve precision, safety, and efficiency across these domains.

Globally, AI has advanced rapidly, powering models that predict intraoperative and postoperative hypotension, hypoxaemia, and depth of anaesthesia.[4,6] Deep-learning algorithms can now analyse physiological waveforms and optimise ventilator settings, while explainable AI systems identify key biomarkers and guide early interventions in critical illness.[8] However, most of these innovations are built from datasets in high-income countries, limiting their direct applicability in our regional context.[6] For Malaysia and Southeast Asia, the next critical step is to generate robust local data, validate predictive models, and ensure that AI-driven solutions reflect our patient demographics, healthcare resources, and clinical priorities. Strengthening digital infrastructure as well as fostering collaboration

between clinicians and data scientists will be essential to ensure safe, meaningful, and context-appropriate AI integration.

This issue of Malaysian Journal of Anaesthesiology highlights the potential adaptation of AI within our specialty. The e-learning survey by Chua *et al.* explores anaesthesiology trainees' engagement with online learning platforms, illustrating how AI could potentially enable adaptive learning systems that can personalise content, monitor learner progress, and support competency-based training. The simulation study by Abdul Wahab *et al.* evaluates the BIOBASE biological isolation chamber in containing aerosolised particles during patient transport, an area that could benefit from AI-based environmental sensors and real-time data modelling to strengthen infection control and safety. The predictive study by Md Ralib *et al.* compares intensive care prognostic and renal scores in predicting hospital mortality, reflecting the potential of machine-learning algorithms to refine existing scoring systems for more accurate, context-specific predictions relevant to Malaysian intensive care unit populations. Together, these studies mark a collective shift toward data-informed, technology-enabled, and safety-focused practice, key elements in advancing the digital transformation of anaesthesiology.

Beyond these featured works, several emerging themes illustrate the growing convergence of AI, simulation, and sustainability. The Green Anaesthesia Policy, for instance, could utilise AI-supported environmental monitoring and predictive analytics to optimise anaesthetic gas use, reduce the carbon footprint, and enhance operating theatre efficiency. Case reports on submental intubation techniques and complications from subclavian line injury highlight how AI-integrated augmented and virtual reality technologies may enhance procedural accuracy and airway safety. Collectively, these developments reinforce how AI and immersive technologies can be used to advance both patient safety and environmental stewardship in anaesthetic practice.

As Malaysia progresses toward comprehensive digital healthcare integration, the field of anaesthesiology must continue to lead this transformation. Embedding AI into clinical care, education, and research will ensure that innovation remains ethical, explainable, and locally relevant.[9] The future depends on strong collaboration among clinicians, educators, engineers, and data scientists to ensure that technology amplifies rather than replaces human expertise. Through sustained research and cross-disciplinary partnerships, Malaysian anaesthesiologists can evolve from adopting global innovations to driving regional breakthroughs, setting new standards for safe, intelligent, and compassionate care.

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