Role of AI in improving medical education & surgical training

Artificial Intelligence (AI) has remarkably revolutionised healthcare, allowing delivery of patient-centred care with increased precision and reduced complications[1]. Its integration into medical education and surgical training has become increasingly prevalent[2, 3]. It demonstrates great potential in enhancing training flexibility and efficiency by facilitating advancements in extended reality (XR) simulation, 3D-printing, and telemedicine[4, 5]. This essay aims to explore the applications of AI in medical and surgical education, and to discuss potential challenges that may need to be addressed.

AI has significantly advanced simulation-based training which addresses the common challenges faced in medical and surgical training[6]. As reported in the Royal College of Surgeons of England's "UK Surgical Workforce Census Report 2023", the vast majority of surgical trainees stated having inadequate training opportunities, primarily due to lack of access to theatres[7]. Meanwhile, bedside teaching can vary in quality and quantity depending on various dynamic factors. The incorporation of AI in XR technology creates realistic scenarios that mimic real-life patient encounters and surgical procedures, providing instant personalised feedback according to real-time analysis of an individual's performance[4-6, 8, 9]. These interactive learning platforms benefit medical students and surgical trainees by offering alternative opportunities for hands-on procedural, communication, and clinical decision-making experiences[1, 10]. This also enables training curricula to be better tailored to individual trajectories and needs, for instance, utilising eye-tracker to assess neurosurgeons' requirement of gaze training[6, 8, 10-13]. AI-facilitated self-directed learning platforms such as Ethicon's Laparoscopic Skills Training Platform, are particularly useful in delivering quality laparoscopic and robotics surgical training, especially with the current challenges in accessing the DaVinci® robots and its relevant training due to trainer availability and high cost[5, 6, 12, 14, 15]. Alongside the recent introduction of outcome-based training, this helps trainees undertake flexible training pathways, where difficulty in obtaining adequate cases for continuous learning is often reported[16]. Simulated cases incorporated with different biopsychosocial considerations also increase trainees' exposure to patient cases and surgical procedures that are demographically less common, while providing a safe space for mistakes to be made and reflected upon without risking patients' safety[12, 17].

In line with the emergence of patient-centred medicine, the steadfast AI-driven advancement in 3D-visualisation and 3D-printing has transformed surgical teaching and improved practical exercises for enhancing motility and dexterity skills in various surgical fields[5, 18-20]. 3D-visualisation technology, such as UNiD Spine analyzer, provide greater visualisation of the complex patient-specific anatomy in comparison to traditional 2D-imaging, allowing trainees to better understand the dynamic risk-benefit profile of various surgical approaches and decision-making processes during pre-operative planning. However, the process of converting 2D-imaging into 3D-reconstruction files for 3D-printing can be time-consuming and expertise-dependent. The Axial3D Insight Medical Image Segmentation Platform has driven the automation of this process, accelerating the creation of patient-specific 3D models which makes training for patient-centred care more accessible and cost-effective[21]. This technology may be further integrated with real-time feedback in augmented reality simulation as an adjunct to cadaveric, XR-simulated, and real case-based training. This provides a controlled yet interactive setting for trainees to trial different approaches and make pre-operative modifications adapted to patient-specific parameters based on simulated outcomes, thus empowering them to improve their skills in pre-, intra-, and post-operative planning to optimise surgical outcomes. These models can later be recycled for general anatomy teaching to promote the appreciation of anatomical variations and improve the preservation of valuable human specimens. A database of these 3D casefiles can be created for universal access and retrieval, creating more practice opportunities to meet the unmet demand.

Furthermore, AI promotes globalisation in surgical training and skill sharing locally, nationally, and internationally. AI-assisted telemedicine, such as VSI Holomedicine, has helped eliminate geographical barriers and allow virtual assistance in complex surgical cases[11, 22]. This subsequently creates further opportunities for remote person-to-person surgical trainings. Additionally, AI has helped break down language barriers. Large Language Models like ChatGPT are instrumental in promoting inter-specialty surgical learning by simplifying specialist terminology into different forms in adaptation to individual learning styles, including mind maps, to enhance readability for both specialists and non-specialists to broaden their expertise[23].

The increase in non-clinical administrative workload has evidently impacted the quality of surgical training globally, resulting in a significant reduction in direct patient care to as low as 10%[24]. AI has shown the capacity to alleviate this burden clinically which may indirectly secure/protect surgical training time for trainees.

Despite the potential benefits of AI-augmented training, it does not diminish the importance of real-life clinical and surgical experiences. Overreliance on AI may lead to significant downfalls in healthcare delivery[1, 24]. Tolsgaard et al. analogise this with AI-powered autonomous cars which improve driver performance yet fail to advance driving skills[1]. Similarly, passive dependence on AI-generated feedback can hinder the development of critical thinking and selfreflective learning skills that are essential for personal and professional growth[1, 10]. AI algorithms may also contain built-in biases based on the quality of derived datasets[1, 11]. Patient-centred medical decisions are influenced by a complexity of bio-psycho-social factors that AI algorithms may not identify[24, 25]. Without early recognition and intervention, this could cascade into inaccurate feedback on a large scale, which less experienced trainees and students are particularly vulnerable to[11, 24]. This necessitates a revision of training curricula to include comprehensive education on AI applications and potential pitfalls[24, 26, 27]. Lastly, patient data confidentiality and security are critical concerns in AI-facilitated training and should be regulated by a universally established regulatory framework[1, 11]. A systematic appraisal of this cutting-edge technology is required to assess its impact and guide its future direction[3, 6].

In conclusion, as part of the multidisciplinary team, AI technology is not to substitute, but to empower medical education and surgical training. By utilising XR-simulation, 3D-printing and telemedicine, AI can directly and indirectly enhance skill acquisition and expand access to training opportunities across multiple dimensions. While its limitations must be proactively recognised and addressed, collaborative effort between the education sector and AI is necessary to harness its potential in remoulding the next generation of medical and surgical training, which will ultimately improve clinical performance and patient-centred healthcare on a global scale.

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