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Artificial Intelligence Surgery

Editorial

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Artificial intelligence HPB surgery - current problems, future solutions?

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In the inaugural editorial of this journal, Andrew Gumbs described artificial intelligence (AI) as follows: "AI involves the use of a computer to interpret a situation and/or help accomplish a task, and in short to make our lives easier and better"[1]. Other definitions are available but this premise, that AI should be a tool to help us solve the real, urgent, existing problems in our clinical practice is paramount to the promise of AI for hepato-pancreato-biliary (HPB) surgery.

AI consists of several subfields. Machine learning (ML) and deep learning (DL) are algorithms structured to mimic the human brain to be able to interpret more complex situations and make better decisions. Natural language processing (NLP) emphasizes building a computer's ability to understand human language and is crucial for large scale analyses of content such as electronic medical record data, as well as language translation. Computer vision (CV) is a specific area of AI that enables computers to effectively perceive and understand visual things, like x-rays, scans, pathology slides and operative video. Enhanced computer vision with augmented reality, virtual reality, and mixed reality are fields of AI that are considered to have the greatest potential to positively improve surgical outcomes and reduce complications[2].

The promise of AI lies in developing synergy between its subfields as well as with other computing technology to analyse data and generate clinical support. Integration of multimodal data with AI can augment surgical decision-making across all phases of care both at the individual patient and at the population level. Hashimoto describes an integrated AI "collective surgical consciousness" serving as a conduit to add individual patient data to a population dataset while drawing from population data to provide clinical decision support during individual cases[3].

PROBLEMS IN HPB SURGERY AND POSSIBLE AI SOLUTIONS

The US philosopher Abraham Kaplan once wrote "Give a small boy a hammer, and he will find that everything he encounters needs pounding". AI is undoubtedly a powerful and exciting new tool. Its application in medicine and specifically in HPB surgery, requires rigorous scientific evaluation. The end-points must be clinically relevant too, for example safer surgery, fewer complications, better oncological margins, cost-effectiveness and increased long-term survival, if AI is to avoid Kaplan's trap. *Artificial Intelligence Surgery* is the first journal to focus exclusively on the interface of computers and the art of surgery and, fortunately for researchers in this field, no shortage of problems exist in HPB surgery that need pounding.

Liver and pancreatic surgery is technically complex and requires careful preoperative planning and intraoperative execution from highly-trained surgeons, anaesthetists and nursing staff. Despite recent improvement in outcomes, achieved largely through specialisation and centralisation of services, the postoperative morbidity remains high at 20%-30%, and mortality rates for some of the more complex resections can be as high as 10%[4-6]. Moreover, long-term survival for people with HPB malignancies are among the lowest. Worse still, their position relative to other cancers has deteriorated, as more rapid progress is being made in the treatment of e.g. breast, skin and prostate cancer[7]. Can AI provide solutions to this dismal situation?

One clear use of AI in HPB surgery involves the use of 3D visualisation, to delineate complex liver and pancreatic anatomy and its relationship to the tumour. Opportunities exist to improve outcomes, such as operative time, duration of liver inflow occlusion and complications, especially if the opportunity is taken to perform virtual surgery before the real event. Intra-operative use of AI in HPB surgery involves associating the 3D reconstructed images or physical models to the actual surgery. Augmented Reality can be used to display virtual information based on real images of the patient to improve oncological surgery, delineating the ideal dissection plane and anatomical landmarks in real-time to help achieve safe margins with maximum functional preservation[8].

At present, robotic surgery seems like a form of minimally invasive surgery rather than AI. However, this is an oversimplification because the true power of robotic surgery exists in its potential to create autonomous actions[1]. The concept of autonomy, or independent decision making, is central to AI in surgery and the future of surgical robotics. Autonomy is not an "all-or-nothing" concept but a continuum. Initially, it may be preferable for only parts of surgical procedures, such as an anastomosis, to become fully automated, if safe and proven to provide patient benefit. Autonomous dissection may be the riskiest part of surgery to be done autonomously and should be evaluated later[2]. Full robotic surgical autonomy could eventually be possible but will require convincing evidence of superiority before the control of a human surgeon, fully capable of performing and completing the procedure, is relinquished.

Laparoscopic cholecystectomy (LC) is one of the most commonly performed operations worldwide, with between 750,000-1,000,000 performed in the USA alone, every year. A recent Society of American

Gastrointestinal and Endoscopic Surgeons (SAGES) consensus conference on prevention of bile duct injury (BDI) during cholecystectomy identified that its incidence still occurs at a frequency higher than the 0.1%-0.2% rate reported in the open cholecystectomy era[9]. This situation exists despite advances in instrumentation, imaging, surgical techniques, as well as the considerable educational efforts by SAGES and other organisations. Given the devastating nature of this complication for the patient (and the surgeon), can AI offer any solutions to this persisting problem?

Madani and colleagues have explored the ability of deep learning models to identify anatomical landmarks, as well as safe and dangerous zones of dissection during LC and to assess their performance compared to expert annotations[10]. Videos of LC were used to train deep neural networks to identify the safe zone of dissection (Go zone) and the dangerous zone of dissection (No-Go zone). The deep learning models produced a consistent yet dynamic video overlay to distinguish these zones. Such an intra-operative overlay tool could provide augmented reality feedback to surgeons to provide real-time guidance. Remarkably, already a number of commercially available ML-driven platforms are available, whose utility during LC are being assessed[11]. This work is at an early stage of development and the ultimate measure of its success will be safer surgery and specifically, reduced BDI during LC.

Early prediction of morbidity with detailed attention and thorough postoperative management of complications can positively impact the overall outcomes of complex HPB procedures. Can AI do this better than existing tools? Early experience with machine learning suggests that it may. When a machine learning technique was applied to a dataset of 15,657 HPB and colorectal surgery patients, it had a better predictive ability (C-statistic) than other established methods, like the American College of Surgery risk calculator or that of the American Society of Anaesthesiologists[12].

The role of radiomics in the field of hepatobiliary oncology is based on the expectation that a radiologic phenotype, extracted and analysed from computed tomography, positron emission tomography or magnetic resonance imaging, can imitate a cancer's genetic variations and help determine the expected tumour behaviour. Radiomic models have already shown promise in the accurate prediction of early recurrence for hepatocellular and pancreatic cancer[13,14]. Similarly, AI evaluation of histologic pathology specimens as well as the proteins and metabolites within the liver, pancreas and adjacent tumors will advance our ability to precisely diagnose and treat HPB disease. These models have the potential to inform clinical decision making, especially in the use of precision oncology.

WHY WE SET UP THIS SPECIAL HPB ISSUE OF ARTIFICIAL INTELLIGENCE SURGERY

Over the past decade, enhanced preoperative imaging and visualization, improved delineation of the complex anatomical structures of the hepatobiliary system and pancreas, and intra-operative technological advances have helped deliver HPB surgery with increased safety and better postoperative outcomes. AI has a major role to play in 3D visualization, virtual simulation and augmented reality that will help in the training of surgeons and the future delivery of conventional and robotic HPB surgery. Artificial neural networks and machine learning have the potential to revolutionise individualised patient care during the preoperative imaging and postoperative surveillance phases[15].

Artificial Intelligence Surgery has launched a special issue, called "Role of Artificial Intelligence in HPB Surgery". The goal is to provide up-to-date, evidence-based literature, as well as expert-guided practice to understand the current status of artificial intelligence application in HPB surgery and the prospects for future developments in this field. Ultimately, we hope to help realise the promise of AI, to solve the urgent problems inherent to our specialty and make our lives, and patients' lives, "easier and better".

DECLARATIONS

Authors' contributions

Made substantial contributions to conception and design of the study and performed data analysis, data acquisition and interpretation, as well as provided administrative, technical, and material support: O'Reilly DA, Pitt HA

Availability of data and materials

Not applicable.

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Conflicts of interest

Both authors declared that there are no conflicts of interest.

Ethical approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

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