Editorial

AI in Laparoscopic Surgery Training

Dimitrios Filippou

Research and Education Institute in Biomedical Sciences (REIBS), Piraeus-Athens, Greece
School of Medicine, National and Kapodestrian University of Athens, Athens, Greece

Artificial intelligence (AI) is increasingly being integrated into various fields of medicine, including training in laparoscopic surgery. Laparoscopic surgery is a minimally invasive surgical technique that involves the use of small incisions and specialized tools to perform surgical procedures. Laparoscopic training is essential to ensure that surgeons can perform these complex procedures with the highest level of skill and safety. Here are some of the benefits of using AI for laparoscopic surgery training:

Improve skill acquisition. Artificial intelligence can provide realistic simulations of laparoscopic surgery, allowing surgeons to practice and hone their skills in a virtual environment. This can lead to faster skill acquisition as surgeons can perform more operations without the need for a live patient. In addition, AI-based simulations can provide surgeons with feedback and guidance, helping them identify areas for improvement. One of the main advantages of using AI in laparoscopic surgery training is the ability to provide personalized guidance. AI systems can analyze student performance and provide specific feedback and suggestions to help them improve. This personalized instruction helps students develop their skills more quickly and efficiently and improve their performance in the OR. AI systems can also be used to identify patterns in surgeries and provide insights into best practices and potential areas for improvement. By analyzing large datasets of surgical procedures, AI systems can identify common errors and provide guidance on how to avoid them. This helps students develop their skills more quickly and efficiently and improve their performance in the operating room. Another advantage of using AI in laparoscopic surgery training is the ability to provide real-time feedback. The AI system can analyze students' performance during the procedure and provide real-time information and guidance. This helps students correct errors as they occur and develop their skills more quickly and effectively. Despite the many potential benefits of using AI in laparoscopic surgery training, there are challenges that need to be addressed. Technical limitations, such as the need for precise tracking of surgical instruments, can affect the effectiveness of these systems. In addition, ethical considerations such as the potential for over-reliance on technology and the need for human oversight must be taken into account.

Improve efficiency. AI can streamline the training process for laparoscopic surgery by automating certain tasks, such as creating a personalized training plan or tracking a student's progress. This frees up trainers to focus on other aspects of training, such as training students in person.

Enhance Safety. Laparoscopic surgery is inherently risky, and the use of artificial intelligence in training can help reduce the risk of surgical errors. By providing realistic simulations and feedback, AI can help surgeons identify potential risks and practice risk mitigation techniques.

Cost Effectiveness. Training in traditional laparoscopic surgery can be expensive due to the need for live patients, specialized equipment, and experienced instructors. AI-based simulations can significantly reduce training costs while providing a more consistent and standardized training experience.

The application of artificial intelligence and digital technologies is increasingly gaining the attention of experts and universities around the world. Surgeons learn about a useful tool that promises to transform current surgical approaches and improve the efficiency and safety of surgical care worldwide. But what are the most promising applications of AI in surgical training and practice? Here are some of the main applications of AI in laparoscopic surgery:

Simulations. AI-based simulations can provide students with a realistic and immersive environment to practice and hone their skills. These simulations replicate complex surgical scenarios, allowing students to learn and practice in a safe and controlled environment. In addition, AI can provide students with real-time feedback, helping them identify areas for improvement.

Personalized training. Artificial intelligence can be used to create a personalized training plan for each learner, taking into account their skill level, experience and learning style. This helps to increase the effectiveness of the training as each learner can focus on the areas where they most need improvement.

Surgical planning. AI can be used to plan and optimize surgical procedures, taking into account factors such as the patient's anatomy, the surgical site, and the skill level of the surgical team. This helps reduce the risk of surgical errors and complications. AI can also play a role in preoperative planning. By analyzing medical records, scans and other patient data, AI algorithms can help surgeons plan the most effective surgical approach and predict potential complications even before surgery begins. However, it is important to note that AI is not designed to replace human surgeons. Instead, AI is designed to augment and assist surgeons in their work. Human expertise and judgment are always essential to the success of any surgical procedure, and AI should be used as a tool to support and enhance the work of skilled surgeons.

Robotics. Surgical robots with artificial intelligence are becoming more common in laparoscopic surgery, allowing surgeons to perform complex procedures with greater precision and control. These robots can be programmed to perform specific tasks, such as sewing or manipulating tissue, freeing up the surgeon's hands for other tasks.

Data analysis. AI can be used to analyze surgical data, such as video recordings of procedures or patient outcomes, to identify patterns and trends. The data can be used to improve surgical techniques, improve training programs, and develop new surgical tools and techniques.

The most popular applications of modern technology that use AI algorithms are virtual reality simulations and augmented reality visualizations. Their main applications include education and training, and until recently they were not used for diagnostic or treatment purposes.

Virtual reality (VR) simulations are becoming an increasingly popular tool in endoscopic surgery. Laparoscopic surgery is a minimally invasive surgical technique that requires a high level of skill and precision, so it is important that surgeons receive extensive training before performing these procedures on patients. Traditionally, training in laparoscopic surgery involves hands-on experience with live patients, which can be very time-consuming,

expensive and risky. However, with the advent of virtual reality simulation technology, surgeons can now practice and hone their skills in a safe and controlled environment. In a virtual reality simulator, a surgeon puts on a headset and uses specialized tools to perform virtual surgery on a computer-generated patient. Simulation software provides a realistic and interactive environment that allows surgeons to practice different surgical techniques and procedures. Surgeons also receive real-time feedback on their performance, allowing them to identify areas of improvement and improve their skills over time. One of the greatest benefits of VR simulation in laparoscopic surgery training is the ability to replicate the variety of scenarios and complications that can arise during a real surgical procedure. Surgeons can practice managing unexpected events, such as bleeding or organ damage, in a safe and controlled environment, improving their confidence and decision-making skills. In addition, virtual reality simulations offer a cost-effective way to train surgeons. Because the simulation can be repeated as many times as necessary, surgeons can practice until they are confident and ready to operate on live patients. This helps reduce the number of complications and errors during the actual surgery, improve patient outcomes and reduce healthcare costs.

Augmented reality (AR) technology has revolutionized the field of endoscopic surgery by providing students with a highly interactive and immersive experience. AR technology improves the visualization of anatomy and surgical procedures, increases the precision of surgery and reduces the risk of complications. Using AR visualization in laparoscopic surgery allows students to practice complex surgical procedures in a safe and controlled environment without the need for real patients. Using augmented reality, students can view and interact with virtual 3D models of organs and tissues, providing a more realistic and detailed representation of the surgical field. Augmented reality displays also allow for real-time feedback, allowing participants to accurately measure their performance and adjust their technique accordingly. This technology can be used in both basic and advanced surgical training, providing novice and experienced surgeons with a powerful tool to hone their skills. In addition, augmented reality visualization can improve the overall efficiency of surgical procedures by reducing operating time and reducing the risk of complications. Technology can also improve communication and collaboration between surgical teams, resulting in a more coordinated and efficient workflow. Overall, the use of AR visualization in laparoscopic surgery training is an invaluable tool to improve surgical precision, reduce the risk of complications, and improve the overall efficiency of surgical procedures. As augmented reality technology continues to evolve, it will undoubtedly become an essential part of surgical training and practice.

Haptic feedback devices. Tactile feedback devices are becoming an increasingly popular training tool in endoscopic surgery. These devices provide the user with a sense of touch, allowing them to feel feedback from the virtual environment in which they develop. In laparoscopic surgery, haptic feedback devices can provide a more realistic simulation of the surgical environment, helping students develop skills and improve performance. One of the main benefits of haptic feedback devices in laparoscopic surgery training is the ability to improve patient safety. Using haptic feedback devices, students can practice surgical techniques in a safe and controlled environment without the risk of harming real patients. This allows them to gain confidence and experience before performing the

procedure on real patients. Another advantage of haptic feedback devices is the ability to reduce surgical errors and complications. By providing real-time feedback to users, these devices can help students identify and correct errors when they occur. This can lead to better surgical results and fewer complications after surgery. Tactile feedback devices can also personalize student learning. By adjusting the level of feedback and the difficulty of the simulation, the device can adapt to the user's skill level, providing a personalized training experience. This helps students develop at their own pace and develop their skills in the most effective way. While haptic feedback devices offer many advantages in laparoscopic surgery training, there are also challenges that need to be addressed. Technical limitations, such as the need for precise tracking of surgical instruments, can affect the effectiveness of these devices. Ethical considerations, such as the possibility of surgical desensitization, must also be taken into account.

Intelligent tutoring systems. An Intelligent Learning System (ITS) is a computer system that uses artificial intelligence (AI) to provide users with personalized and adaptive education. In laparoscopic surgery training, ITS can be an invaluable tool for students to develop skills and improve performance. A major advantage of ITS in endoscopic surgery training is the ability to provide individualized instruction. By adapting to the individual needs of users, these systems can personalize the training experience to improve learning outcomes. Intelligent Transportation Systems (ITS) can adjust difficulty, provide performance feedback, and suggest improvements based on user performance. Another advantage of ITS is the ability to provide real-time feedback to users. In laparoscopic surgery, students must be able to perform the procedure quickly and accurately. The Intelligent Transfer System (ITS) provides immediate feedback on a learner's performance, allowing them to correct mistakes and improve skills more quickly. ITS can also be used to improve the efficiency of traditional training methods in endoscopic surgery. By integrating ITS into existing training programs, students receive more customized and personalized training. This results in better retention of knowledge and skills and better intraoperative performance. Despite the many potential benefits of ITS for laparoscopic surgery training, there are challenges that need to be addressed. Technical limitations, such as the need for precise tracking of surgical instruments, can affect the effectiveness of these systems. In addition, ethical considerations such as the potential for over-reliance on technology and the need for human oversight must be taken into account.

Machine Learning Algorithms. Machine learning (ML) algorithms are becoming an increasingly popular training tool for laparoscopic surgery. These algorithms use large data sets to train models that can analyze and explain surgical procedures, allowing students to learn from past cases and improve their skills. One of the main advantages of ML algorithms in laparoscopic surgery training is the ability to quickly and accurately analyze large amounts of data. By analyzing past surgical cases, these algorithms can identify patterns and provide insights into best practices and potential areas for improvement. This allows students to learn realistic surgical procedures and develop their skills more effectively. Another advantage of machine learning algorithms is the ability to provide personalized instructions. By analyzing learner performance and identifying areas for improvement, these algorithms can tailor the training experience to improve learning

outcomes. This results in better retention of knowledge and skills and better surgical performance. ML algorithms can also be used to improve the efficiency of traditional training methods in endoscopic surgery. By integrating machine learning algorithms into existing training programs, students can receive more personalized and adaptive training. Despite the many potential advantages of ML algorithms for endoscopic surgery training, there are some challenges that need to be addressed. Technical limitations, such as the need for large data sets and advanced computing power, can affect the efficiency of these algorithms. In addition, ethical considerations such as potential bias must be taken into account when analyzing datasets. We strongly believe that machine learning algorithms have the potential to revolutionize laparoscopic surgery training. By analyzing large data sets, providing personalized guidance, and improving the efficiency of existing training methods, machine learning algorithms can help students develop their skills and improve their performance in the operating room. As research and development continues, machine learning algorithms may become an important tool in surgical training in the future.

Artificial intelligence challenges in laparoscopic surgery training. Despite the many potential benefits of using AI in laparoscopic surgery training, some challenges must also be addressed. Some of these challenges include technical limitations, ethical considerations, and the need for ongoing research and development. A major technical limitation of AI in laparoscopic surgery training is the need for precise tracking of surgical instruments. This requires sophisticated tracking systems that can precisely monitor the position and movement of instruments during surgery. If the tracking system is not accurate, the AI system's feedback and recommendations can be useless or even harmful. Another challenge with using AI for laparoscopic surgery training is the potential for over-reliance on the technology. Students may over-rely on AI systems for guidance and feedback, resulting in a lack of critical thinking and decision-making skills. Additionally, there may be concerns that the analysis of datasets used by AI systems is biased, which may affect the accuracy and effectiveness of the recommendations made. Technical considerations are also important factors to consider when using AI in laparoscopic surgery. For example, there may be concerns about patient privacy and the security of sensitive medical data. Additionally, there may be concerns that AI systems could replace human teachers, leading to job losses in the medical field. Finally, further research and development is needed to further improve the effectiveness of AI in laparoscopic surgery training. This includes developing more sophisticated monitoring systems, improving the algorithms used in artificial intelligence systems, and conducting rigorous clinical trials to assess the safety and effectiveness of these systems.

In conclusion, the incorporation of AI into training for laparoscopic surgery has the potential to revolutionize the way surgeons are trained. By providing realistic simulations, personalized instructions and automated monitoring, AI can help surgeons gain the skills and experience needed to perform laparoscopic surgery with the highest level of safety and efficiency.

References

1) Moglia A, Georgiou K, Georgiou E, Satava RM, Cuschieri A. A systematic review on artificial intelligence in robot-assisted surgery.

Int J Surg. 2021 Nov; 95: 106151. doi: 10.1016/ j.ijsu.2021. 106151

2) Levi Sandri GB, Abu Hilal M, Dokmak S, Edwin B, Hackert T, Keck T, Khatkov I, Besselink MG, Boggi U; E-AHPBA Innovation & Development Committee. Figures do matter: A literature review of 4587 robotic pancreatic resections and their implications on training. J Hepatobiliary Pancreat Sci. 2023 Jan;30(1):21-35. doi: 10.1002/jhbp.1209

3) Humm G, Harries RL, Stoyanov D, Lovat LB. Supporting laparoscopic general surgery training with digital technology: The United Kingdom and Ireland paradigm. BMC Surg. 2021 Mar 8;21(1):123. doi: 10.1186/s12893-021-01123-4

4) Wee IJY, Kuo LJ, Ngu JC. A systematic review of the true benefit of robotic surgery: Ergonomics. Int J Med Robot. 2020 Aug;16(4):e2113. doi: 10.1002/rcs.2113

5) Batista Rodríguez G, Balla A, Corradetti S, Martinez C, Hernández P, Bollo J, Targarona EM. What have we learned in minimally invasive colorectal surgery from NSQIP and NIS large databases? A systematic review. Int J Colorectal Dis. 2018 Jun;33(6):663-681. doi: 10.1007/s00384-018-3036-4

6) Bric JD, Lumbard DC, Frelich MJ, Gould JC. Current state of virtual reality simulation in robotic surgery training: a review. Surg Endosc. 2016 Jun;30(6):2169-78. doi: 10.1007/s00464-015-4517-y