Magna Scientia Advanced Research and Reviews
eISSN: 2582-9394
Cross Ref DOI: 10.30574/msarr
Journal homepage: https://magnascientiapub.com/journals/msarr/

(Review Article)

Revolutionizing colorectal surgery with artificial intelligence: Enhancing surgical skills and accelerating the learning curve

Ali Mohtashami [1, 2, *], Rebecca Seton [1], Justin Evans [1] and Kah Hoong Chang [1, 2]

[1] *Department of Colorectal Surgery, Royal North Shore Hospital, Australia.*
[2] *Northern Clinical School, University of Sydney, Sydney, Australia.*

Magna Scientia Advanced Research and Reviews, 2025, 13(02), 109-112

Publication history: Received on 12 February 2025; revised on 01 April 2025; accepted on 04 April 2025

Article DOI: https://doi.org/10.30574/msarr.2025.13.2.0047

Abstract

Background: Advances in Artificial intelligence (AI) have been significant in recent years; the combination of AI and Robotic Colorectal Surgery is transforming the field of surgery, offering innovative solutions to enhance surgical education and practice

Methods and Results: This paper aims to review the use of AI and its future in Colorectal Surgery. We specifically looked into the potential of how AI technologies may reshape surgical education and training, accelerate skill acquisition, and improve surgical outcomes. By evaluating the latest research and clinical evidence, we gain insights into the effectiveness of AI in reducing the learning curve for colorectal surgery and its implications for the future of surgical practice.

Conclusion: Integrating AI technologies into colorectal surgery may represent a paradigm shift in surgical education, practice, and patient care. By leveraging AI-powered systems, colorectal surgeons can overcome traditional challenges, accelerate skill acquisition, and achieve superior patient outcomes.

Keywords: Artificial intelligence; Robotic surgery; Colorectal surgery; learning curve; Surgical Education.

1. Introduction

Artificial intelligence (AI) is transforming the field of surgery, offering innovative solutions to enhance surgical education and practice [1]. AI uses algorithms that allow computers and humans to reason, problem-solve, and assist in decision-making [2]. In this article, we examine the impact of AI on the learning curve of colorectal surgeons. We explore how AI technologies may reshape surgical education and training, accelerate skill acquisition, and improve surgical outcomes. By evaluating the latest research and clinical evidence, we gain insights into the effectiveness of AI in reducing the learning curve for colorectal surgery and its implications for the future of surgical practice.

AI is defined as the ability of a digital computer or computer-controlled robot to perform tasks commonly associated with intelligent beings [2]. In addition to robotic surgery, AI possesses several unique vital characteristics that could contribute to its effectiveness in assisting surgeons' skills acquisition, including an enhanced visualization platform, improved agility and ergonomics, real-time feedback, and assistance and integration of advanced technologies [3, 4]. Furthermore, incorporating AI into surgical training may shorten the learning curve by various practical applications.

AI can be classified into two main categories:

* Corresponding author: Ali Mohtashami

- Data-driven AI:
  - Data-driven AI uses a large data base to train models for predictions and decisions, relying on techniques (4)
- Knowledge-based AI
  - Uses a formal representation of knowledge to make decisions and inferences using reasoning and logic (4)

1.1. AI in Colorectal Surgery

AI-powered surgical simulators and virtual reality platforms may provide trainee surgeons with immersive, hands-on experiences in a controlled, risk-free environment. These simulated training environments allow surgeons to practice various colorectal procedures, from basic techniques to advanced manoeuvres [6,7]. Repeating surgical tasks and scenarios in virtual settings will enable trainees to refine their skills, develop muscle memory, and gain confidence before transitioning to real-world surgical cases. This simulated training approach may shorten the learning curve by accelerating the acquisition of essential surgical skills and reducing the time needed for supervised practice [6,7].

1.2. Personalized training programs

AI algorithms analyse individual trainee performance data and provide personalized feedback and guidance based on specific learning objectives and skill levels. By adjusting training programs to each surgeon's learning needs, AI-powered systems optimize the learning process and address areas of weakness or improvement. Trainees can track their progress over time, monitor performance metrics, and receive targeted interventions to enhance their proficiency in colorectal surgery. The Smart Tissue Autonomous Robot system, developed at Johns Hopkins University [7], is an example. Another example is diffuse reflectance spectroscopy during colonoscopy to distinguish normal colorectal walls from colorectal cancer tissue and different colorectal polyps [6,7]. Similarly, indocyanine green was used in the dynamic assessment of healthy tissue perfusion and cancer, with an accuracy of up to 86.4% [9]

1.3. Real-time guidance and assistance

During live surgical procedures, AI-powered robotic systems provide real-time guidance and assistance to surgeons, particularly those in the early stages of their learning curve. AI algorithms analyze intraoperative data, such as tissue characteristics and instrument positioning, and provide instant feedback to surgeons to optimize their technique and decision-making [10]. This real-time guidance minimizes errors, reduces the risk of complications, and accelerates the learning curve by allowing surgeons to learn from immediate feedback and adjust their approach accordingly [11].

1.4. Continuous learning and improvement

AI-powered systems facilitate learning and improvement by capturing and analyzing vast amounts of surgical data from multiple sources, including electronic health records, surgical videos, and patient outcomes databases [11]. Machine learning algorithms identify patterns, trends, and best practices in colorectal surgery, allowing surgeons to stay updated on the latest advancements and evidence-based techniques [12].

2. Challenges and Future Directions:

Integrating AI technologies holds immense promise for enhancing colorectal surgery, but several challenges and considerations must be addressed to realize its full potential.

2.1. Cost and accessibility:

One of the primary challenges associated with AI-powered surgical technologies is the acquisition, implementation, and maintenance cost. Robotic-assisted surgery systems, in particular, require significant financial investment, which may limit access to these technologies in resource-limited settings or smaller healthcare institutions [12]. Addressing cost-effectiveness and affordability concerns will ensure equitable access to AI-driven surgical innovations, especially in underserved communities and developing regions.

2.2. Training and education:

While AI-enabled simulation and training platforms offer valuable opportunities for surgical education, integrating these tools into existing training curricula poses logistical and educational challenges. Surgeons and trainees require comprehensive training programs to use AI technologies effectively and maximize their benefits. Additionally, ensuring standardized proficiency assessments and credentialing processes for AI-assisted surgical procedures is essential for maintaining quality and safety standards across healthcare institutions [14,15].

2.3. Ethical and regulatory considerations:

The widespread adoption of AI in colorectal surgery raises important ethical and regulatory considerations regarding patient safety, privacy, and liability. When using AI-powered systems in clinical practice, surgeons must navigate ethical dilemmas related to informed consent, data privacy, and algorithmic bias. Regulatory agencies and professional organizations are vital in developing guidelines, standards, and oversight mechanisms to ensure AI technologies' ethical and responsible use in surgery [12].

2.4. Interdisciplinary collaboration:

The successful integration of AI in colorectal surgery requires interdisciplinary collaboration among surgeons, engineers, data scientists, and other healthcare professionals. Collaborative efforts are needed to develop and refine AI algorithms, validate predictive models, and optimize clinical workflows for seamless integration into surgical practice [12].

3. Several future directions hold promise for advancing the field of AI in colorectal surgery:

3.1. Augmented reality and haptic feedback:

Integrating augmented reality (AR) and haptic feedback technologies into AI-powered surgical systems can enhance surgeons' spatial awareness and tactile feedback during colorectal procedures. AR overlays and tactile sensations provide real-time guidance and sensory feedback, enabling surgeons to perform complex maneuvers more confidently and precisely [13].

3.2. Predictive analytics and decision support:

AI-driven predictive analytics and decision support tools can assist surgeons in preoperative planning, intraoperative decision-making, and postoperative monitoring. AI algorithms can identify risk factors, predict outcomes, and recommend personalized treatment strategies for colorectal surgery patients by analyzing patient-specific data, such as imaging studies, laboratory results, and clinical variables [14,15].

3.3. Collaborative robotics and telesurgery:

Collaborative robotics and telesurgery platforms enable remote assistance and collaboration among surgeons, facilitating knowledge exchange and skill transfer across geographical barriers. Surgeons can leverage AI-powered teleoperation systems to perform colorectal procedures in real-time, receive guidance from expert mentors, and participate in collaborative surgical teams, regardless of their physical location [14].

3.4. Continuous innovation and adaptation:

AI in colorectal surgery is rapidly evolving, with ongoing technological, research, and clinical practice advancements. Continuous innovation and adaptation are essential for staying at the forefront of surgical excellence and addressing emerging challenges and opportunities in colorectal surgery [16].

4. Conclusion

integrating AI technologies into colorectal surgery may represent a paradigm shift in surgical education, practice, and patient care. By leveraging AI-powered systems, colorectal surgeons can overcome traditional challenges, accelerate skill acquisition, and achieve superior patient outcomes. Throughout this review, we explored the future impact of AI on the learning curve of colorectal surgeons. AI technologies offer innovative solutions to enhance surgical proficiency and performance, from simulated training environments to real-time guidance and assistance during live surgical procedures. These systems provide enhanced visualization, improved agility, real-time feedback, and integration of advanced technologies, enabling surgeons to perform with unprecedented precision and efficiency. By tailoring training programs to individual needs and skill levels, AI accelerates the learning curve and empowers surgeons to achieve mastery in less time.

Compliance with ethical standards

Disclosure of conflict of interest

The authors have not received any grant support and declare no conflicts of interest. All authors agree with the manuscript's content, which has not been published previously and is not under consideration elsewhere.

References

[1] Mascagni P, Padoy N. Or black box and surgical control tower: Recording and streaming data and analytics to improve surgical care. Journal of Visceral Surgery. 2021 Jun;158(3). doi:10.1016/j.jviscsurg.2021.01.004

[2] Hashimoto DA, Rosman G, Rus D, Meireles OR (2018) Artif icial intelligence in surgery: Promises and perils. Ann Surg 268(1):70–76

[3] Copeland B (2020) Artificial intelligence. Encyclopedia Britannica. https://www.britannica.com/technology/artifi cial-intelligen ce. Accessed 16 Sep 2022

[4] Payday N. Machine and deep learning for workflow recognition during surgery. Minim Invasive Ther Allied Technol [Internet]. 2019;28(2):82–90. Available from: http://dx.doi.org/10.1080/13645706.2019.1584116

[5] Pandey B, Mishra RB (2009) Knowledge and intelligent computing system in medicine. Comput Biol Med 39(3):215–230. https:// doi.org/10.1016/j.compbiomed.2008.12.008

[6] Baltussen EJM, Snaebjornsson P, de Koning SGB, Sterenborg H, Aalbers AGJ, Kok N, Beets GL, Hendriks BHW, Kuhlmann KFD, Ruers TJM (2017) Diffuse reflectance spectroscopy as a tool for real-time tissue assessment during colorectal cancer surgery. J Biomed Opt 22(10):1–6. https:// doi. org/ 10. 1117/1. JBO. 22. 10. 106014 39.

[7] Baltussen EJM, Brouwer de Koning SG, Sanders J, Aalbers AGJ, Kok NFM, Beets GL, Hendriks BHW, Sterenborg H, Kuhlmann KFD, Ruers TJM (2019) Tissue diagnosis during colorectal cancer surgery using optical sensing: an in vivo study. J Transl Med 17(1):333. https://doi.org/10.1186/s12967-019-2083-0"https://doi.org/10.1186/s12967-019-2083-0

[8] Shademan A, Decker RS, Opfermann JD, Leonard S, Krieger A, Kim PC (2016) Supervised autonomous robotic soft tissue surgery. Sci Transl Med 8(337):337. https:// doi. org/ 10. 1126/ scitr anslmed.aad9398

[9] Cahill RA, O'Shea DF, Khan MF, Khokhar HA, Epperlein JP, Mac Aonghusa PG, Nair R, Zhuk SM (2021) Artificial intelligence indocyanine green (ICG) perfusion for colorectal cancer intra-operative tissue classification. Br J Surg 108(1):5–9. https:// doi.org/10.1093/bjs/znaa004

[10] Ward TM, Fer DM, Ban Y, Rosman G, Meireles OR, Hashimoto DA. Challenges in surgical video annotation. Comput Assist Surg (Abingdon) [Internet]. 2021;26(1):58–68. Available from: http://dx.doi.org/10.1080/24699322.2021.1937320

[11] Kitaguchi D, Takeshita N, Matsuzaki H, Oda T, Watanabe M, Mori K, et al. Automated laparoscopic colorectal surgery workflow recognition using artificial intelligence: Experimental research. Int J Surg [Internet]. 2020;79:88–94. Available from: http://dx.doi.org/10.1016/j.ijsu.2020.05.015

[12] Quero G, Mascagni P, Kolbinger FR, Fiorillo C, De Sio D, Longo F, et al. Artificial intelligence in colorectal cancer surgery: Present and future perspectives. Cancers (Basel) [Internet]. 2022;14(15):3803. Available from: http://dx.doi.org/10.3390/cancers14153803

[13] Porpiglia F, Checcucci E, Amparore D, Autorino R, Piana A, Bellin A et al (2019) Augmented-reality robot-assisted radical prostatectomy using hyper-accuracy three-dimensional reconstruction (HA3D™) technology: a radiological and pathological study. BJU Int 123(5):834–845

[14] Ward TM, Fer D, Ban Y, Rosman G, Meireles OR, Hashimoto DA (2021) Challenges surg video annotation. Comp Assisted Surg 26(1):58–68

[15] Porpiglia F, Checcucci E, Amparore D, Autorino R, Piana A, Bellin A et al (2019) Augmented-reality robot-assisted radical prostatectomy using hyper-accuracy three-dimensional reconstruction (HA3D™) technology: a radiological and pathological study. BJU Int 123(5):834–845

[16] Cruz Rivera S, Liu X, Chan A-W, Denniston AK, Calvert MJ, Ashrafian H, et al. Guidelines for clinical trial protocols for interventions involving artificial intelligence: the SPIRIT-AI extension. Lancet Digit Health [Internet]. 2020;2(10):e549–60. Available from: http://dx.doi.org/10.1016/s2589-7500(20)30219-3