Walker *et al. Art Int Surg.* 2025;5:345-9
**DOI:** 10.20517/ais.2025.02

**Artificial Intelligence Surgery**

**Perspective**

**Open Access**

Check for updates

# From surgical outcome prediction to optimizing surgical performance: the role of artificial intelligence in hernia surgery

**Victoria L. Walker[1], B. Todd Heniford[2], Gregory T. Scarola[3], Sullivan A. Ayuso[2]**

[1]Department of Surgery, Baptist Memorial Hospital, Memphis, TN 38120, USA.
[2]Division of Gastrointestinal and General Surgery, Department of Surgery, Endeavor Health, Evanston, IL 60201, USA.
[3]Division of Gastrointestinal and Minimally Invasive Surgery, Department of Surgery, Carolinas Medical Center, Charlotte, NC 60202, USA.

**Correspondence to:** Dr. Sullivan A. Ayuso, Division of Gastrointestinal and General Surgery, Department of Surgery, Endeavor Health, Room B665, 2650 Ridge Ave, Evanston, IL 60201, USA. E-mail: sullivan.ayuso@gmail.com

**How to cite this article:** Walker VL, Heniford BT, Scarola GT, Ayuso SA. From surgical outcome prediction to optimizing surgical performance: the role of artificial intelligence in hernia surgery. *Art Int Surg.* 2025;5:345-9. https://dx.doi.org/10.20517/ais.2025.02

**Received:** 13 Jan 2025 **First Decision:** 27 May 2025 **Revised:** 2 Jun 2025 **Accepted:** 12 Jun 2025 **Published:** 7 Jul 2025

**Academic Editor:** Andrew Gumbs **Copy Editor:** Pei-Yun Wang **Production Editor:** Pei-Yun Wang

## Abstract

Artificial intelligence (AI) is starting to change the way we approach hernia surgery and abdominal wall reconstruction (AWR). From improving surgical planning to predicting outcomes and enhancing intraoperative precision, AI, particularly deep learning models (DLMs), offers tools that can support decision making and personalize patient care. These models can analyze large datasets, such as preoperative imaging, to spot patterns we might miss. We have seen AI outperform experienced surgeons in predicting complications like mesh infections. Despite its promise, there are also valid concerns about data quality, transparency, and overreliance. Thoughtful integration is essential, ensuring that AI complements rather than replaces clinical judgment. Moving forward, collaboration with fields such as computer science and support from surgical societies will be essential. With appropriate groundwork, AI can be a powerful tool in the pre-op, intra-op, and post-op phases of care.

**Keywords:** Artificial intelligence, deep learning, algorithm, hernia, abdominal wall reconstruction, surgery

Artificial intelligence (AI) refers to computer systems designed to mimic human cognition. AI has the capacity to perform both routinized and complex tasks, such as learning and problem-solving, and is rapidly transforming medicine. In hernia surgery and abdominal wall reconstruction (AWR), AI has played a role in improving surgical planning, enhancing precision during procedures, and predicting patient outcomes[1]. By analyzing large amounts of data and identifying patterns that might be missed or unrecognized by humans, AI has the potential to make hernia surgery safer and more efficient. The aim of this perspective piece is to advocate for a balanced integration of AI into hernia surgery, highlighting its benefits, challenges, and future implications. Additionally, it emphasizes the importance of fostering collaboration with non-medical disciplines such as computer science and data analytics to advance AI-driven surgical innovation.

The first instances of AI integration in medicine aimed to diagnose specific medical pathologies, such as diabetic retinopathy and intracranial hemorrhage[2,3]. Hernia surgery was the first field of medicine where AI algorithms were used specifically to predict patient outcomes[4]. Outcome prediction was performed with the development of deep learning models (DLMs), a subset of AI that focuses on enabling machines to learn from data in either a supervised or unsupervised fashion. Supervised learning utilizes known, labeled outputs to train AI algorithms, while unsupervised learning relies on algorithms to recognize relationships in a given dataset and train itself. Machine learning (ML) involves teaching systems to recognize patterns and make decisions based on data, while deep learning, a more advanced subset, uses specialized neural networks with many layers to analyze and appropriately weigh the importance of complex information[5]. DLMs are particularly adept at processing and analyzing visual data such as images and videos and provide a means for objectively assessing large amounts of information. These models learn to identify patterns, objects, or features through supervised or unsupervised learning and are trained and then tested on novel data. Applications of these models include object detection, facial recognition, and medical imaging analysis[5].

Using preoperative CT imaging, Elhage and colleagues were able to predict surgical site infections in AWR patients with 85% accuracy and demonstrated that DLMs were more successful than expert hernia surgeons in predicting the need for component separation techniques[4]. Since that seminal publication, there have been other examples whereby objective preoperative data are used to predict hernia outcomes. For example, the models developed by Elhage were modified by Ayuso *et al*., who generated additional instances of "rare" surgical outcomes to train DLMs and were able to improve the ability of models to detect instances of mesh infection and pulmonary failure[1]. Moreover, Lesch *et al*. have recently demonstrated how hernia repairs may be improved by biomechanical analyses, such as assessments of hernia and mesh size, suture factors, and tissue stability[6]. AI-driven analysis of CTs that evaluate biomechanical properties of hernias may increase the precision of hernia repair. Ultimately, the interplay between preoperative imaging and patient data can both be used for predictive modeling, but this has not yet been done.

By analyzing large datasets of patient images and demographic information, these models can identify patterns that indicate surgical risk and can help to effectively stratify patients. This would allow surgeons to make tailored risk assessments and informed decisions, improving both preoperative planning and postoperative care. Though external validation is needed before widespread use, the ultimate goal of these AI models is to personalize the care of the hernia patient and improve the quality of life of patients, which remains the principal goal of the hernia surgeon. The external validation of AI models, along with the development of AI models based on multicenter data, is a requisite task before they are more broadly generalizable[7]. The ability to anticipate complications and surgical complexity can aid in planning the safest surgical approach and identifying potential anatomical challenges. In addition, patients who are deemed at particularly high risk given their comorbidities and risk stratification using AI algorithms may be triaged to tertiary hernia centers to receive care. Patients who are at risk for a mesh infection may be followed for several years after their surgery, as mesh-related complications may take years to present[8]. Similarly, patients who are deemed at lower risk for complications may be appropriately operated on closer to home to promote appropriate resource utilization for AWR patients.

The use of AI in hernia surgery extends beyond outcome prediction. For instance, a group led by Takeuchi from the IRCAD institute helped to develop an AI model that identified the phases of a laparoscopic inguinal hernia repair through video review[9]. The phases of these operations were linked with experience level and were postulated to help with monitoring surgical training and even increasing operating room efficiency. Using AI in the operating room could also aid in assessing the completeness of an operation (e.g., the critical view of the myopectineal orifice) and in recognizing key anatomical structures, such as identifying the semilunar line during a minimally invasive transversus abdominis release. The robotic platform may not only adjust its instruments and camera based on visual cues, but eventually, it may be able to assist or complete parts of the procedure. Robotics can also provide data on surgeon ergonomics and kinematics, which can aid in surgical coaching and improve surgical performance.

While the use of AI algorithms in the preoperative and intraoperative phases of hernia surgery is already being defined, the role of AI in the postoperative phase is less clear. As mentioned, if patients are identified to be at risk for a postoperative complication, they may be followed by the surgical team for a longer time period postoperatively or have their care altered at the time of surgery. For instance, a patient at high risk of pulmonary failure may be monitored in the intensive care unit. Similarly, a patient at high risk of hernia recurrence may receive a more robust mesh overlap or even a different type of mesh. An area that is ripe for investigation is the use of AI to detect complications or deviations from the standard postoperative pathway. Data from automated patient monitoring systems may be leveraged to accurately determine patients exhibiting abnormal vital signs or physiological disturbances that may indicate impending clinical deterioration[10].

While promising in its application in hernia surgery, the widespread adoption of AI has also been critiqued. Some argue that using AI models for preoperative planning lacks reliability and promotes overreliance on a technology that we do not fully understand[5]. For example, in the DLMs that were developed using CT images, we are unable to decode the black box and know what features of the images are important when predicting outcomes. AI models are only as good as the data they are trained on. If the training data are incomplete, biased, or not representative of diverse patient populations, the model's predictions may be inaccurate or misleading[11]. This could lead to suboptimal surgical plans or overconfidence in AI-generated recommendations. Prematurely marketing certain AI models or applications may actually have an adverse effect on the integration of this technology in the long term and negatively impact public perception. It is important that AI augment, rather than replace, clinical knowledge and gestalt, ensuring that patient care is improved rather than compromised. AI is not only limited by the integrity of the data for model development, but to this point, still relies on surgeons to have the technical skill to carry out its recommendations. AI should enable healthcare providers to become more efficient and focus on what is most important.

There should be a reframing of how AI is used in clinical medicine and hernia surgery. AI models should be viewed as decision-support tools, providing additional insights to complement a surgeon's clinical judgment[12]. Moreover, surgeons remain the ultimate decision-makers, critically evaluating and adapting the model's recommendations based on their expertise and real-time observations. AI has the capacity to supplement rather than supplant the role of the surgeon. Having more information at the disposal of surgeons can lead to more informed clinical decision making and improve patient outcomes. Hernia surgery, as much as any other discipline, is rapidly evolving. The number of hernia surgeries performed in the United States has increased compared to a decade ago[13]. As a relatively young subspecialty, hernia surgery continues to evolve rapidly. Novel surgical techniques are published each year, accompanied by a growing emphasis on academic productivity aimed at generating high-quality data[14]. Now more than ever is the appropriate time to embrace AI technology to navigate the changing landscape of hernia surgery and to continue providing the highest standard of care for our patients.

There are two factors that have the potential to positively influence AI's adoption in the hernia community, and the two are interconnected. The first factor is the generation of large-scale data. The data consist of social and demographic information, preoperative imaging, operative technique, and postoperative outcomes. While the utilization of institutional data is important to track outcomes and improve surgeon performance, the authors recognize that maximum AI utility will require big data collected over long periods of time[15]. Structured and well-formulated efforts should be made on the front end to organize and standardize data for AI processing. Contrary to the relative immediacy by which AI can process data, the planning and thought that would go into formulating the gathering of data for meaningful AI model development would be time- and resource-intensive. The second factor that would help lead to the efficient and widespread adoption of AI platforms is buy-in from surgeon leaders and surgical societies. Societies like the American Hernia Society and registries like the Abdominal Health Core Quality Collaborative have the opportunity to lead the way in warehousing data from surgeons that can be used to enhance outcome prediction models, refine operative techniques through video review, and gather postoperative information that will help define hernia care.

Engaging in collaborative projects with non-medical disciplines such as computer science and data analytics is an opportunity for advancing AI in the surgical field. Such interdisciplinary collaboration fosters a synergistic relationship where each field enhances the other, driving innovation and improving the quality of care. Surgeons understand the clinical needs, challenges, and intricacies of surgical procedures, which are critical for developing relevant AI solutions. Computer scientists bring skills in algorithm design, ML, and big data analytics, enabling the creation of robust and scalable AI models. Collaboration ensures that AI tools are clinically relevant, user-friendly, and designed to address real-world surgical problems. Furthermore, collaborating with data scientists can introduce surgeons to new technologies and research methodologies, fostering ongoing innovation. Just like subspecialization in the surgical field, relying on other professionals with specific training helps to fill in knowledge gaps that surgeons are unfamiliar with.

AI holds immense potential to enhance outcomes and precision and optimize patient care. However, it needs careful implementation and interdisciplinary collaboration to address ethical, practical, and technological challenges. By fostering collaborations among surgeons, data analysts, and computer scientists, the surgical community can ensure that AI-driven advancements are both transformative and patient-centered. In hernia surgery, the future of AI should focus on supporting all stages of care - preoperative, intraoperative, and postoperative. Although AI has significant potential for integration into clinical care, its use in surgical care remains limited. Further organized efforts by surgical societies and organizations to store and leverage large-scale data could facilitate the development of AI models and technologies for routine clinical use. Ultimately, the advancement of hernia surgery - and medicine more broadly - may depend on the pace at which AI is adopted in clinical practice.

## DECLARATIONS

### Authors' contributions

Responsible for the conceptualization and drafting of the original manuscript, as well as the final editing: Walker VL, Heniford BT, Ayuso SA

Responsible for manuscript editing: Scarola GT

**Availability of data and materials**

Not applicable.

**Financial support and sponsorship**

None.

**Conflicts of interest**

Heniford BT received education grant money and honoraria for speaking from WL Gore. The other authors declared that there are no conflicts of interest.

**Ethical approval and consent to participate**

Not applicable.

**Consent for publication**

Not applicable.



## REFERENCES

1. Ayuso SA, Elhage SA, Zhang Y, et al. Predicting rare outcomes in abdominal wall reconstruction using image-based deep learning models. *Surgery.* 2023;173:748-55. DOI PubMed
2. Arbabshirani MR, Fornwalt BK, Mongelluzzo GJ, et al. Advanced machine learning in action: identification of intracranial hemorrhage on computed tomography scans of the head with clinical workflow integration. *NPJ Digit Med.* 2018;1:9. DOI PubMed PMC
3. Gulshan V, Peng L, Coram M, et al. Development and validation of a deep learning algorithm for detection of diabetic retinopathy in retinal fundus photographs. *JAMA.* 2016;316:2402-10. DOI PubMed
4. Elhage SA, Deerenberg EB, Ayuso SA, et al. Development and validation of image-based deep learning models to predict surgical complexity and complications in abdominal wall reconstruction. *JAMA Surg.* 2021;156:933-40. DOI PubMed PMC
5. Hashimoto DA, Rosman G, Rus D, Meireles OR. Artificial intelligence in surgery: promises and perils. *Ann Surg.* 2018;268:70-6. DOI PubMed PMC
6. Lesch C, Nessel R, Adolf D, et al; STRONGHOLD/Herniamed-Collaborators GROUP. STRONGHOLD first-year results of biomechanically calculated abdominal wall repair: a propensity score matching. *Hernia.* 2024;28:63-73. DOI PubMed PMC
7. Lorenz WR, Holland AM, Sarac BA, et al. Development of multicenter deep learning models for predicting surgical complexity and surgical site infection in abdominal wall reconstruction, a pilot study. *J Abdom Wall Surg.* 2025;4:14371. DOI PubMed PMC
8. Kao AM, Arnold MR, Augenstein VA, Heniford BT. Prevention and treatment strategies for mesh infection in abdominal wall reconstruction. *Plast Reconstr Surg.* 2018;142:149S-55S. DOI PubMed
9. Takeuchi M, Collins T, Ndagijimana A, et al. Automatic surgical phase recognition in laparoscopic inguinal hernia repair with artificial intelligence. *Hernia.* 2022;26:1669-78. DOI PubMed
10. McGillion MH, Duceppe E, Allan K, et al; PROTECT Network Investigators. Postoperative remote automated monitoring: need for and state of the science. *Can J Cardiol.* 2018;34:850-62. DOI PubMed
11. Obermeyer Z, Powers B, Vogeli C, Mullainathan S. Dissecting racial bias in an algorithm used to manage the health of populations. *Science.* 2019;366:447-53. DOI PubMed
12. Topol EJ. High-performance medicine: the convergence of human and artificial intelligence. *Nat Med.* 2019;25:44-56. DOI PubMed
13. Schlosser KA, Renshaw SM, Tamer RM, Strassels SA, Poulose BK. Ventral hernia repair: an increasing burden affecting abdominal core health. *Hernia.* 2023;27:415-21. DOI PubMed
14. Köckerling F, Hoffmann H, Mayer F, et al. What are the trends in incisional hernia repair? Real-world data over 10 years from the Herniamed registry. *Hernia.* 2021;25:255-65. DOI PubMed
15. Ngiam KY, Khor IW. Big data and machine learning algorithms for health-care delivery. *Lancet Oncol.* 2019;20:e262-73. DOI PubMed