International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Use of Artificial Intelligence in the Surgical Field: Advantages and Implications

Carlos Alexandre Gomes Passarinho Menezes[1], Yohan Schmidt Krubniki[2], Marcelo Bertolucci Fonseca[2], Lucas Nunes Viltrakis[2], Roberto Pereira Correa[3], João Victor Texeira Colares[3], João Victtor Silva Pantoja[3], Sarah Gama Ghersberg[4], Rodrigo Petraccho Betarelli[5]

[1,2]Medical School, University of Ribeirão Preto, Guarujá, State of São Paulo, Brazil.
[3]Medical School, Centro Universitário Metropolitano da Amazônia, Belém, Pará State, Brazil.
[4]Medical School, Estácio de Sá University, Rio de Janeiro, State of Rio de Janeiro, Brazil.
[5]MD, MHS and Professor, University of Ribeirão Preto, Guarujá, State of São Paulo, Brazil.
DOI: https://doi.org/10.55248/gengpi.5.0124.0337

A B S T R A C T

Introduction: It is evident that we are on the brink of a future filled with revolutionary possibilities ranging from risk reduction to improved decision-making. However, artificial intelligence (AI) is a novel tool and raises ethical concerns in its application.

Objectives: To analyze the current use of AI in the surgical field and its implications.

Methods: This is a narrative review conducted on the National Library of Medicine (NLM) databases from the past 5 years. This process consisted of four stages: identification, selection, eligibility, and inclusion.

Results: Algorithms can provide estimates of success probabilities, potential complications, and postoperative recovery. This approach allows surgeons to guide patients more precisely and engage in shared decision-making.

Conclusion: This tool does not replace surgeons' decision-making but serves as a valuable aid in the pursuit of the best outcome. The success of this approach depends on the harmony between human knowledge and machine processing capabilities.

Keywords: Artificial intelligence, surgical procedures, machine learning, deep learning

1. Introduction

The intersection of medicine and technology has yielded remarkable advancements, and Artificial Intelligence (AI) has emerged as a transformative tool in this domain. It has been employed across various aspects, primarily in applications for diagnostics in radiology and pathology, extending to more therapeutic and interventional uses in cardiology and surgery[1]. In recent years, the integration of AI in medicine has significantly altered the approach to surgical procedures.

These systems arose from the need to interpret large volumes of data (Big Data), being capable of analyzing both simple and complex data rapidly and accurately, adapting to them without static programming[2]. Consequently, the application of AI in the surgical realm has provided valuable insights to enhance the entire surgical process, from preoperative planning, surgical simulation modeling, outcome prediction, prognosis, to postoperative care.

AI, with its ability to analyze complex data and identify patterns, has found a useful domain in surgery, opening doors to new approaches that optimize outcomes and improve intervention efficiency. Deep Learning (DL) algorithms are being applied to enhance real-time tracking of surgical instruments and phase segmentation, thereby increasing surgical safety and assisting in the evaluation and education of surgical trainees[3].

Preliminary data suggest that DL models are theoretically capable of accurately predicting the risk of perioperative and postoperative complications, thereby enhancing recommendations for their management[4]. This is because automated analysis of preoperative clinical data could provide a more specific patient risk score for operative planning, consequently offering valuable predictions for postoperative care, enhancing real-time decision-making by the surgeon[5]. In this sense, AI enriches and refines the traditionally experience-based and guideline-driven approach.

This moment is of great importance but delicacy. As we delve into the applications and implications of AI, it becomes evident that we stand on the threshold of a future filled with revolutionary possibilities, ranging from risk reduction to improved decision-making. However, being a novel tool, it still has some reservations in its application. AI algorithms are susceptible to data distortions, basic research biases (sampling, blinding, etc.), and implicit and explicit biases in the healthcare system that can significantly impact the data used or will be used to train AI[5]. Among other challenges is the need for reliable and ethical data, as well as considerations around medical autonomy, specific knowledge, and financial issues.

Understanding how AI is currently used in the surgical realm and its implications is crucial for the advancement of the specialty. Therefore, this work comprehensively and critically explores the tangible and effective integration of AI into surgical procedures. By highlighting this, we seek to comprehend how AI revolutionizes the modern scientific landscape, emphasizing its advantages and implications.

2. Methods

This current study constitutes a narrative review. Accordingly, a search for English-language scientific articles was conducted on digital scientific databases, specifically the National Library of Medicine (NLM), which aggregates records from the MEDLINE database (the primary database produced by NLM) containing unique PubMed and LILACS records. No restrictions were applied to the type of study, and the descriptors (DeCS/MeSH) utilized were "Artificial Intelligence," "Surgical Procedures," "Machine Learning," and "Deep Learning." These were employed in the form of search strings: "Artificial Intelligence" and "Surgical Procedures" and "Machine Learning," "Artificial Intelligence" and "Surgical Procedures," and "Surgical Procedures" and "Machine Learning."

Inclusion criteria encompassed works that established a connection between the surgical field and AI within the past 5 years. Articles lacking technical approach, a focus on surgery, or sufficient details regarding the application of artificial intelligence were excluded.

The initial selection of articles was conducted through title readings, assessing their relevance to the objectives of this study. Based on the analysis of the articles, results were synthesized to identify trends, patterns, and relevant insights regarding the effectiveness of artificial intelligence in surgery. Successful case examples and situations where AI application was investigated for significant improvements in surgical outcomes were highlighted.

Subsequently, each article underwent comprehensive reading and critical analysis, considering their pertinence. This process comprised four stages: identification, selection, eligibility, and inclusion. The chosen articles were scrutinized for their contribution to understanding the integration of AI into surgical procedures, ensuring a rigorous evaluation in line with the objectives of this scientific endeavor.

3. Results

The application of AI in surgical planning has been revealed as a revolutionary tool, altering the traditional approach to the preparation and execution of surgical procedures. The results indicate that AI has been successfully employed in various areas of surgical planning, offering a range of benefits that positively impact precision, efficiency, and surgical outcomes.

AI plays a crucial role in the surgical chain by enabling automated analysis of complex data to assist in identifying critical areas and assessing risks. This tool has the potential to provide information for the detection and decision support of Surgical Site Infection (SSI). As we transform SSI data into disease intelligence, the possibility of enhancing surgical practice with the promise of an optimized future for the highest quality patient care is increased[6]. Pathologists, for instance, have utilized AI to reduce the error rate in recognizing positive lymph nodes for cancer from 3.4% to 0.5%[5].

This innovation is also applied in heart failure (HF) through phenotype distinction, allocating patients into different disease signature profiles, enabling the selection of individuals with the highest benefit for various therapies[7]. In cardiology, AI can be used for additional analysis of baseline ECG to identify patients for a better response to cardiac resynchronization therapy (CRT)[8].

Furthermore, the modeling of surgical simulations has immensely benefited from AI. Virtual simulation systems allow the creation of realistic surgical environments, enabling surgeons to practice and refine their skills before the actual procedure. Thus, AI is used for monitoring, predicting events, guidance, management, and surgical room logistics[1]. A special application is the EOS™ (ATEC Spine Group, Paris, France), which allows 3D simulation through the analysis and recognition of patterns from computed tomography (CT) datasets of the axial skeleton and semi-automatic calculations of length and angle based on a 2-DX digital X-ray image[9]. This not only reduces motion anxiety but also offers the opportunity to experiment with different approaches and tactics, increasing confidence and improving decision-making.

In the realm of medical image analysis, computer vision algorithms identify anatomical details with notable precision, aiding in preoperative visualization and allowing a more comprehensive assessment of the involved structures. This capacity for detailed analysis provides a solid foundation for more informed planning. A significant example is CoviDet, an AI developed to accurately diagnose COVID-19 based on CT scans with or without clinical data[10]. With this technology, it is possible to monitor and predict a patient's clinical course.

The prediction of surgical outcomes is another domain where AI demonstrates its value. In a prospective study, the algorithm predicted postoperative complications more accurately than physicians[11]. The My Surgery Risk platform uses data from electronic health records (EHR) for 285 variables to predict 8 postoperative complications and mortality at 1, 3, 6, 12, and 24 months with high accuracy[12]. In this regard, a study by Shickel[13] indicates that when applied to the same set of variables used to calculate Sequential Organ Failure Assessment (SOFA) scores, DL models outperform traditional SOFA modeling in predicting hospital mortality for ICA patients.

Thus, by analyzing clinical, radiological, and other relevant parameters, algorithms can provide estimates of success probabilities, potential complications, and postoperative recovery. This approach enables surgeons to guide patients more precisely and collaborate in shared decision-making.

4. Discussion

The data obtained in this study underscore that AI has transformed the way surgeons operate. The convergence of surgical expertise with AI capability has led to notable advancements, particularly in the modeling of surgical simulations, outcome prediction, and optimization of intervention strategies. The observed positive effects have been consistent, including the reduction of surgical errors, decision-making enhancement, and overall optimization of operating time.

Diagnostic and judgment errors represent the second most common cause of avoidable harm suffered by surgical patients[4]. Surgical decision-making is hindered by time constraints, uncertainty, complexity, decision fatigue, hypothetical-deductive reasoning, and, notably, bias. The traditional decision support system is compromised by manual data entry delays and suboptimal accuracy. Surgical decision-making faces major challenges in complexity, values and emotions, time constraints, and uncertainty.

Complexity in the traditional hypothetical-deductive decision-making model dominates the scene. A list of possibilities differentiated by empirical tests and therapies is required, depending on each surgeon's capacity. Values are inherently individualized, preventing a standardized ideal decision-making pattern[14], and emotions surround the acute surgical condition, generating a sense of urgency and pressure on the physician to perform straightforward operations[15].

Concerning time constraints and uncertainty, decisions related to urgent or emergent conditions must be made before all relevant data is available and analyzed. Furthermore, decisions may be compromised by time constraints and uncertainty due to the high volume of decision-making. In an assessment of medical student and resident presentations in intensive care units (ICUs), potentially important data were omitted in 157 out of 157 presentations[16].

These deficiencies are exacerbated by acute and chronic sleep deprivation, occurring in up to two-thirds of all internally attending intensive care surgeons[17]. Thus, automated AI models with live-streamed EHR data can address these weaknesses. However, even as an excellent tool, it still depends on the physician for its correct functioning and alignment with its potential.

Therefore, AI can be broadly defined as the study of algorithms that give machines the ability to reason and perform cognitive functions, such as problem-solving, object and word recognition, and decision-making[5]. It is crucial to understand that it has two extensions, machine learning (ML) and deep learning (DL). The former is a practice of using algorithms to gather data, learn from it, and then decide or prediction, but to be useful and reliable, it constantly depends on the input of real data[18]. This is because DL is the extreme of interactive and adaptive learning; it can establish neural connections and diversity to integrate different databases.

However, the path to full AI implementation is not without challenges. Obtaining robust and well-labeled datasets is a fundamental requirement to train algorithms accurately. AI models trained on erroneous or distorted data are susceptible to obscuring the truth. When the data used to train an algorithm predominantly comes from patient populations with demographics different from where it is applied, accuracy is compromised.

The Framingham Heart Study, for example, mainly included white participants. A model trained on this data may reflect racial and ethnic biases because associations between cardiovascular risk factors and events differ by race and ethnicity[4]. This may particularly affect minorities due to the long-term underrepresentation of patient records and clinical studies.

Ethical issues also emerge in this scenario. The global adversarial judicial system is well-equipped to handle scenarios where a doctor is responsible for making the wrong decision, but assigning blame to a program and its developers can be more challenging. The main ethical issues arising from the application of AI to surgery concern human agency, accountability for errors, technical robustness, data privacy and governance, transparency, diversity, non-discrimination, and justice[19].

Confidence in AI recommendations may challenge the autonomy of counseling and raise concerns about responsibility in cases of adverse outcomes. Nevertheless, it is crucial to emphasize that AI should be viewed as an aid to decision-making, enriching knowledge, and experience rather than replacing them.

There is a tendency for studies with positive results to be submitted and published. Thus, literature on AI in medicine can be overly optimistic. This is a factor that complicates the accurate measurement of results, and a rigorous analysis for validation and generalization is essential, such as conducting a stress test of AI models, which can better recognize flaws.

In conclusion, the application of artificial intelligence in surgical planning has the potential to revolutionize surgical practice significantly. The ability to model surgical simulations, predict outcomes, and enhance approaches contributes to improved clinical outcomes and more personalized and secure surgery. However, technical, ethical, and implementation challenges must be collaboratively addressed for this innovative approach to reach its full potential for the benefit of patients and the entire medical community.

5. Conclusion

The integration of AI technology into surgery marks a notable progression. The capability of artificial intelligence to interpret complex data and provide personalized and accurate information expands the potential to enhance surgical outcomes and reduce risks. Further exploration and evolution in this area may yield new advancements in modern surgery, proving mutually beneficial for physicians and their patients.

It is evident that this specific tool does not replace the judgment of surgeons but serves as a valuable complement in the pursuit of optimal results. The success of this approach relies on the harmony between human expertise and machine processing capabilities.

References

1. Hashimoto, D. A., Witkowski, E., Gao, L., Meireles, O., & Rosman, G. (2020). Artificial intelligence in anesthesiology: current techniques, clinical applications, and limitations. *Anesthesiology*, *132*(2), 379-394.
2. Awan, S. E., Sohel, F., Sanfilippo, F. M., Bennamoun, M., & Dwivedi, G. (2018). Machine learning in heart failure: ready for prime time. Current opinion in cardiology, 33(2), 190-195.
3. Mishra, K., & Leng, T. (2021). Artificial intelligence and ophthalmic surgery. *Current opinion in ophthalmology*, *32*(5), 425–430.
4. Loftus, T. J., Tighe, P. J., Filiberto, A. C., Efron, P. A., Brakenridge, S. C., Mohr, A. M., Rashidi, P., Upchurch, G. R., Jr, & Bihorac, A. (2020). Artificial Intelligence and Surgical Decision-making. *JAMA surgery*, *155*(2), 148–158.
5. Hashimoto, D. A., Rosman, G., Rus, D., & Meireles, O. R. (2018). Artificial Intelligence in Surgery: Promises and Perils. *Annals of surgery*, *268*(1), 70–76.
6. Samareh, A., Chang, X., Lober, W. B., Evans, H. L., Wang, Z., Qian, X., & Huang, S. (2019). Artificial Intelligence Methods for Surgical Site Infection: Impacts on Detection, Monitoring, and Decision Making. *Surgical infections*, *20*(7), 546–554.
7. Ahmad, T., Wilson, F. P., & Desai, N. R. (2018). The Trifecta of Precision Care in Heart Failure: Biology, Biomarkers, and Big Data. *Journal of the American College of Cardiology*, *72*(10), 1091–1094.
8. Feeny, A. K., Rickard, J., Trulock, K. M., Patel, D., Toro, S., Moennich, L. A., Varma, N., Niebauer, M. J., Gorodeski, E. Z., Grimm, R. A., Barnard, J., Madabhushi, A., & Chung, M. K. (2020). Machine Learning of 12-Lead QRS Waveforms to Identify Cardiac Resynchronization Therapy Patients With Differential Outcomes. *Circulation. Arrhythmia and electrophysiology*, *13*(7), e008210.
9. Rohde, S., & Münnich, N. (2022). Künstliche Intelligenz in der orthopädisch-unfallchirurgischen Radiologie [Artificial intelligence in orthopaedic and trauma surgery imaging]. *Orthopadie (Heidelberg, Germany)*, *51*(9), 748–756.
10. Liang, H., Guo, Y., Chen, X., Ang, K. L., He, Y., Jiang, N., Du, Q., Zeng, Q., Lu, L., Gao, Z., Li, L., Li, Q., Nie, F., Ding, G., Huang, G., Chen, A., Li, Y., Guan, W., Sang, L., Xu, Y., … Zhong, N. (2022). Artificial intelligence for stepwise diagnosis and monitoring of COVID-19. *European radiology*, *32*(4), 2235–2245.
11. Brennan, M., Puri, S., Ozrazgat-Baslanti, T., Feng, Z., Ruppert, M., Hashemighouchani, H., Momcilovic, P., Li, X., Wang, D. Z., & Bihorac, A. (2019). Comparing clinical judgment with the MySurgeryRisk algorithm for preoperative risk assessment: A pilot usability study. *Surgery*, *165*(5), 1035–1045.
12. Bihorac, A., Ozrazgat-Baslanti, T., Ebadi, A., Motaei, A., Madkour, M., Pardalos, P. M., Lipori, G., Hogan, W. R., Efron, P. A., Moore, F., Moldawer, L. L., Wang, D. Z., Hobson, C. E., Rashidi, P., Li, X., & Momcilovic, P. (2019). MySurgeryRisk: Development and Validation of a Machine-learning Risk Algorithm for Major Complications and Death After Surgery. *Annals of surgery*, *269*(4), 652–662.
13. Shickel, B., Loftus, T. J., Adhikari, L., Ozrazgat-Baslanti, T., Bihorac, A., & Rashidi, P. (2019). DeepSOFA: A Continuous Acuity Score for Critically Ill Patients using Clinically Interpretable Deep Learning. *Scientific reports*, *9*(1), 1879.
14. Kopecky, K. E., Urbach, D., & Schwarze, M. L. (2019). Risk Calculators and Decision Aids Are Not Enough for Shared Decision Making. *JAMA surgery*, *154*(1), 3–4.
15. Morris, R. S., Ruck, J. M., Conca-Cheng, A. M., Smith, T. J., Carver, T. W., & Johnston, F. M. (2018). Shared Decision-Making in Acute Surgical Illness: The Surgeon's Perspective. *Journal of the American College of Surgeons*, *226*(5), 784–795.
16. Artis, K. A., Bordley, J., Mohan, V., & Gold, J. A. (2019). Data Omission by Physician Trainees on ICU Rounds. *Critical care medicine*, *47*(3), 403–409.
17. Coleman, J. J., Robinson, C. K., Zarzaur, B. L., Timsina, L., Rozycki, G. S., & Feliciano, D. V. (2019). To Sleep, Perchance to Dream: Acute and Chronic Sleep Deprivation in Acute Care Surgeons. *Journal of the American College of Surgeons*, *229*(2), 166–174.
18. de Marvao, A., Dawes, T. J., Howard, J. P., & O'Regan, D. P. (2020). Artificial intelligence and the cardiologist: what you need to know for 2020. *Heart (British Cardiac Society)*, *106*(5), 399–400.
19. Cobianchi, L., Verde, J. M., Loftus, T. J., Piccolo, D., Dal Mas, F., Mascagni, P., Garcia Vazquez, A., Ansaloni, L., Marseglia, G. R., Massaro, M., Gallix, B., Padoy, N., Peter, A., & Kaafarani, H. M. (2022). Artificial Intelligence and Surgery: Ethical Dilemmas and Open Issues. *Journal of the American College of Surgeons*, *235*(2), 268–275.