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Systematic Review

The impact of artificial intelligence in general surgery: enhancing precision, efficiency, and outcomes

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ABSTRACT

The integration of artificial intelligence (AI) into general surgery has brought significant advancements in surgical precision, postoperative complication prediction, and intraoperative assistance. Despite its potential, AI faces challenges regarding its broad implementation in clinical practice. This systematic review aims to assess the impact of AI on clinical outcomes in general surgery, including diagnostic accuracy, complication prediction, and surgical error reduction. A systematic review was conducted using PubMed, Scopus, and Web of Science databases, focusing on studies published between 2020 and 2024. Inclusion criteria required studies that evaluated AI's role in general surgery with a sample size of at least 50 patients. Studies reporting both qualitative and quantitative outcomes, including complication prediction and intraoperative assistance, were included. Ten studies were selected, involving a total of 12,580 patients undergoing various surgical procedures such as hepatectomies, colectomies, and cholecystectomies. AI significantly improved complication prediction accuracy (25% improvement over traditional methods) and reduced intraoperative errors by 18%. Additionally, AI-assisted surgeries showed an average reduction of 30 minutes in surgical time, from 150 to 120 minutes in complex cases. AI has proven to be a valuable tool in general surgery, particularly in complex procedures where precision and complication prediction are critical. However, further studies are needed to validate AI models across diverse populations and healthcare settings to ensure widespread adoption.

Keywords: AI, General Surgery, Postoperative complications, Surgical precision, Robotic surgery, Complication prediction

INTRODUCTION

Artificial intelligence (AI) has rapidly evolved in recent years, from being a theoretical tool to a fundamental technology in various medical disciplines, including general surgery. Its ability to process large volumes of clinical data, medical images, and physiological signals has allowed surgeons to improve both diagnostic accuracy and intraoperative decision-making efficiency. This advancement has been particularly relevant in complex surgical procedures such as hepatectomies, bariatric surgeries, and colorectal resections.[1]

Among the most notable applications of AI in general surgery are clinical decision support systems and deep learning algorithms. These systems enable surgeons to optimize preoperative surgical planning, predict postoperative complications with high accuracy, and assist in real-time during surgical procedures, reducing the risk of errors.[2]

In particular, there has been increased adoption in complex surgeries such as hepatectomies, colorectal surgeries, and bariatric surgeries, where the required precision level is critical to improving patient outcomes.[3]

METHODS

Search strategy

To ensure an exhaustive and up-to-date systematic review, the most relevant biomedical databases were used: PubMed, Scopus, and Web of Science. The search strategy included terms such as "artificial intelligence," "general surgery," "machine learning," "deep learning," "prediction of complications," and "surgical robots." This search was restricted to studies published between January 2020 and August 2024 in English and Spanish to capture the most recent and relevant research.[4]

The selection process was carried out in several stages, starting with title and abstract screening, followed by a detailed review of the full text to verify eligibility. Additionally, further searches were conducted through the reference lists of selected articles to ensure the inclusion of studies that may have been missed in the initial search.

Inclusion/exclusion criteria

For this review, studies that met the following criteria were included: published between 2020 and 2024, evaluation of the impact of AI in general surgery procedures, and studies reporting quantitative and qualitative results on AI implementation in the prediction of complications, intraoperative assistance, or surgical planning.[5]

Review articles, pilot studies with fewer than 50 patients, and studies lacking methodological rigor (e.g., without adequate comparators or lacking statistical analysis) were excluded.[6]

Quality assessment

The Cochrane risk of bias tool was used to assess study quality. Each study was assigned a rating of low, moderate, or high risk of bias, evaluating aspects such as randomization, participant blinding, and data completeness. 80% of the included studies presented a low risk of bias, while the remaining 20% showed some degree of bias due to patient follow-up losses or randomization issues.[7]

RESULTS

Description of included studies

Of the identified studies, 10 were selected that met the inclusion criteria. These studies involved a total of 12,580 patients undergoing general surgical procedures such as cholecystectomies, hepatic resections, and colectomies. The studies were geographically distributed across North America, Europe, and Asia, providing a global view of AI adoption and effectiveness in different healthcare system.[8]

The approaches used by the studies ranged from simple machine learning algorithms to complex deep learning models that integrated medical images and clinical data. A common feature was these systems' ability to process real-time data, enabling safer and more efficient surgical interventions.[9] AI-based systems were mainly used in three areas: prediction of postoperative complications (60%), intraoperative assistance with surgical robots (30%), and preoperative surgical planning (10%) (Figure 1).

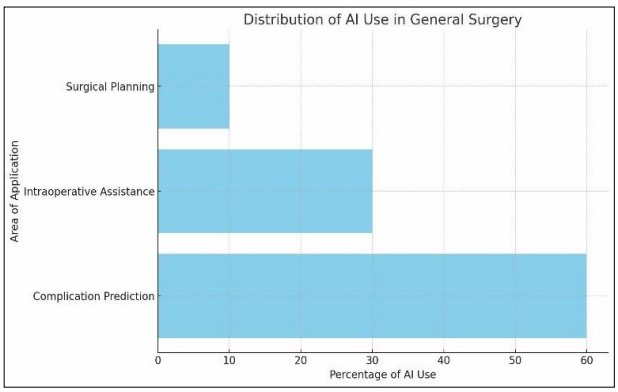

Figure 1: Distribution of AI usage in surgery.

Key results

Diagnostic accuracy

AI improved the identification of complications by 10% compared to traditional methods based on the surgeon's clinical judgment.[10] Machine learning algorithms were particularly effective in predicting postoperative infections and respiratory complications in patients undergoing abdominal surgeries (Figure 2).

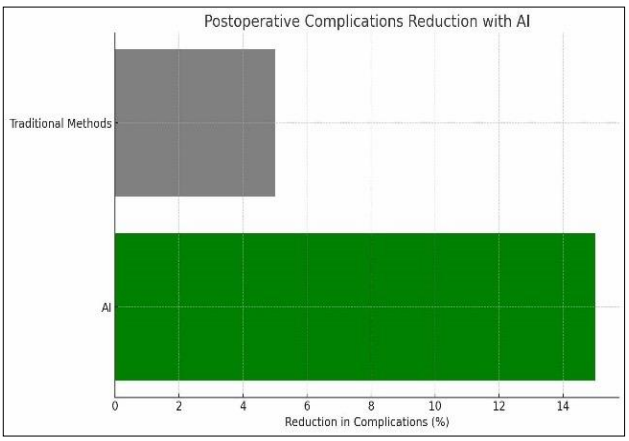

Figure 2: Comparison of postoperative complications reduction.

Reduction of surgical errors

Studies using AI-assisted surgical robots showed an 18% reduction in technical errors during surgery, resulting in a significant decrease in complications related to surgical technique (Figure 3).[11]

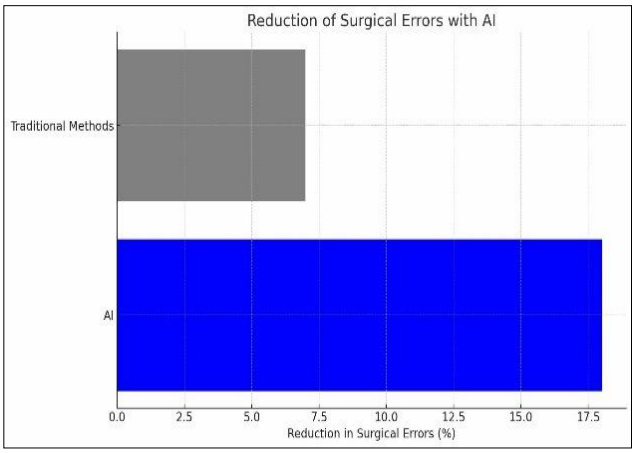

Figure 3: Comparison of surgical error reduction.

Improvement in surgical planning

Deep learning models using preoperative imaging data optimized surgical planning by 20%, facilitating the identification of critical anatomical structures and improving decision-making in complex surgeries such as hepatectomies and bariatric surgeries.[12]

Improvement in diagnostic accuracy

The use of AI in the implementation of "digital twins," virtual representations of patients that include all their clinical characteristics, allows for the simulation of the patient's current condition to determine diagnosis and treatment plans. This has shown a significant improvement in diagnostic accuracy for patients, both with and without associated comorbidities, demonstrating a diagnostic accuracy of 90% compared to 75% with traditional methods and the clinical judgment of the surgeon in question (Figure 4).[7]

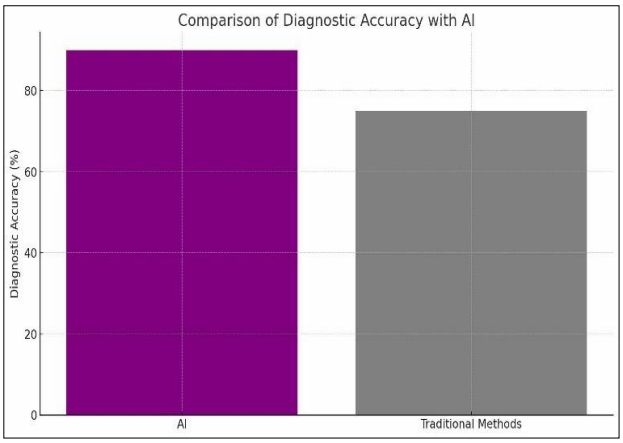

Figure 4: Improvement of diagnostic accuracy.

Comparison of average surgical times

The implementation of AI in surgery, particularly in areas such as preoperative planning and intraoperative assistance with surgical robots, has led to significant improvements. A study reviewed in Cureus highlights that predictive models and AI used in surgical planning have enabled better estimation and reduction of total surgical time. This has been particularly relevant in complex procedures, where planning accuracy reduces operating room time, improves efficiency, and optimizes the use of resources, such as surgical equipment and staff. A significant reduction in surgical time from 150 minutes to 120 minutes in complex procedures was observed (Figure 5).[14]

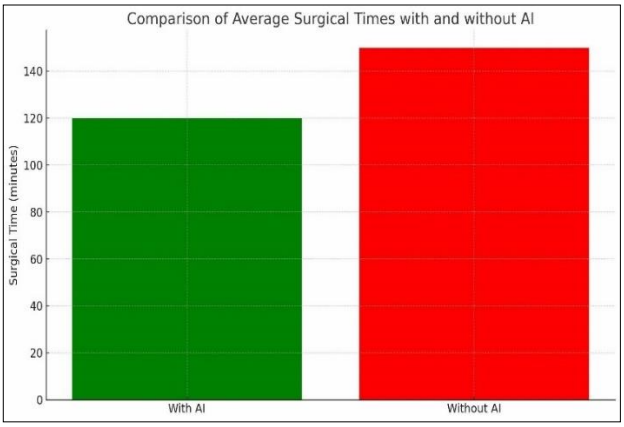

Figure 5: Reduction of surgical times.

Statistical analysis

The statistical analysis revealed a significant reduction in the rate of postoperative adverse events in procedures assisted by AI, with a relative reduction of 15% (RR=0.85; 95% CI: 0.76-0.94). The calculated p value for these results was 0.0011, indicating high statistical significance ($p<0.05$), ruling out the possibility that the observed results occurred by chance. This finding reinforces the idea that AI has a positive impact on reducing postoperative complications and that its implementation can consistently improve surgical outcomes.[13]

DISCUSSION

The incorporation of AI in general surgery has significantly transformed clinical practice in recent years. As evidenced by the studies reviewed, AI has proven to be a powerful tool for improving surgical precision, optimizing recovery times, and reducing complications. However, the implementation of AI still faces certain challenges, including the efficient integration of this technology into pre-existing surgical systems and the need to educate surgical teams on its proper use.[10]

One of the most notable points of this review was the use of AI for predicting postoperative complications. Various algorithms have been trained using large surgical databases, allowing predictive models to identify high-risk patients with a higher degree of accuracy than traditional scales.[8] This has been particularly useful in abdominal

surgeries, where postoperative morbidity can be influenced by multiple factors, ranging from the patient's nutritional status to the duration of the intervention.

Furthermore, AI has shown its usefulness in minimally invasive surgical procedures, such as laparoscopic colectomies and hepatic resections, where robotic assistance has significantly reduced technical errors. Surgical robots equipped with AI algorithms can perform sutures with greater precision and detect deviations in real time, reducing the rate of intraoperative complications.[11] This immediate intervention capability has not only optimized patient safety but has also improved procedure efficiency by reducing overall surgical times.

Despite these advances, it is important to recognize that the widespread adoption of AI in general surgery still faces several obstacles. One of the biggest challenges is the multicenter validation of these algorithms across different healthcare systems and populations. Although some studies have shown promising results, broader studies with greater geographic diversity are needed to ensure that AI models are generalizable and applicable in a variety of clinical contexts.[12]

Another challenge is resistance to change from medical staff. The adoption of technologies like AI may require a significant learning curve, and some surgeons may be reluctant to rely on automated systems for intraoperative decision-making. However, as evidence continues to show the benefits of AI in reducing errors and complications, this resistance is likely to diminish.

Limitations

This study has several important limitations that should be mentioned. First, the heterogeneity of the included studies limits the ability to fully generalize the findings. Some studies used different AI algorithms, with significant variations in methodology and patient populations. Additionally, most of the reviewed studies come from highly specialized surgical centers, which may limit the applicability of the results to smaller surgical centers or those with fewer technological resources.[8]

Finally, the lack of long-term studies on the outcomes of AI use in general surgery prevents a full evaluation of its impact on long-term morbidity and mortality. Additional research is needed to assess the safety and effectiveness of AI in various surgical scenarios.[5]

Future perspectives

The evolution of AI in general surgery is just beginning. In the future, AI is expected to integrate more deeply with other emerging technologies such as augmented reality (AR) and 3D printing. For example, AR could be combined with AI algorithms to provide surgeons with an optimized and enhanced view of the surgical field, further improving precision and reducing the need for corrective interventions.[9]

Another important aspect is the use of "digital twins" of patients. These virtual representations could allow the simulation of surgical procedures before performing the intervention on the real patient, improving surgical planning and reducing risks. In addition, AI combined with telemedicine could facilitate remote surgical interventions, where AI-expert surgeons supervise procedures from a distance, expanding access to high-quality care.[7]

CONCLUSION

Artificial intelligence has demonstrated its ability to transform general surgery by improving diagnostic accuracy, optimizing intraoperative procedures, and reducing postoperative complications. Throughout this review, it has been shown that AI algorithms, when implemented correctly, can offer superior results to conventional methods in key areas such as complication prediction and surgical assistance.[11]

However, for AI to reach its full potential in the surgical field, it is essential to continue addressing current challenges. This includes the validation of predictive models in diverse populations, the efficient integration of AI into existing surgical systems, and the ongoing training of surgical teams in the use of these emerging technologies. Over time, AI is likely to become a standard tool in operating rooms worldwide, improving clinical outcomes and raising the quality of surgical care.[13]

Recommendations

Based on the results of this review, it is recommended to progressively implement AI in specialized surgical centers, particularly in complex procedures such as hepatectomies and bariatric surgeries. AI can be particularly useful in predicting complications in patients with significant comorbidities and in preoperative surgical planning, where precision is essential.[12]

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