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REVIEW

Impact of Artificial Intelligence on Metabolic Bariatric Surgery (MBS) and Minimally Invasive Surgery (MIS): A Literature Review

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Background: Artificial intelligence (AI) is emerging as a transformative force in healthcare, particularly in metabolic bariatric surgery (MBS) and minimally invasive surgery (MIS). This literature review explores AI's applications, advantages, challenges, and future potential in these fields.

Methods: A narrative review of 30 studies, including randomized controlled trials, observational studies, literature reviews, and meta-analyses, was conducted. Critical findings on AI's impact on surgical precision, workflow efficiency, complications, and patient outcomes were synthesized.

Results: AI-enabled techniques significantly improved surgical precision, reduced complication rates, and optimized workflows. AI applications in preoperative planning, intraoperative assistance, and postoperative monitoring demonstrated consistent advantages. However, ethical concerns, data privacy, and standardization issues persist.

Conclusion: AI integration in MBS and MIS has the potential to revolutionize surgical outcomes, enhance precision, and improve efficiency. Addressing interoperability, data security, and regulatory barriers will be crucial for widespread adoption.

Keywords: metabolic bariatric surgery, minimally invasive surgery, artificial intelligence, robotic surgery, precision medicine, surgical efficiency

Introduction

Artificial intelligence (AI) has revolutionized healthcare provision, including diagnoses and treatment strategies, since it was first integrated into numerous medical sectors.[1] Additionally, AI has shown tremendous potential for improving surgical precision, efficiency, and patient outcomes.[2] Surgeons, who treat complex gastrointestinal problems and obesity, focus on metabolic bariatric surgery (MBS) and minimally invasive surgery (MIS); therefore, this literature study aims to elucidate the developments, difficulties, and potential applications of AI technology in metabolic bariatric surgery MBS and MIS.[3]

The worldwide prevalence of obesity and its associated metabolic problems has surged to epidemic levels, resulting in serious health risks and financial difficulties. Metabolic bariatric surgery MBS has been proven to be a successful strategy for achieving long-term weight loss and enhancing metabolic health. Metabolic bariatric surgery MBS leads to type 2 diabetes remission, and it is an established treatment approach for metabolic syndrome.[4] However, metabolic bariatric surgery MBS is complicated, and patients have different anatomy and physiology; therefore, careful planning and execution of surgery are required. Using data analytics, machine learning algorithms, and computer vision techniques, AI-driven technologies have provided potential solutions that can optimize surgical procedures, improve decision-making, and improve patient outcomes.[5] MIS has several advantages, such as reduced postoperative discomfort, shorter hospital stays, and expedited recovery, resulting in its popularity among medical specialties. AI applications in machine intelligence and information science include image guidance, augmented reality, robotic assistance, and many other functions that enable more accurate instrument control and tissue manipulation.[6] These developments may flatten the learning curve related to machine intelligence and information science, enhance surgical skills, and decrease the possibility of complications. Despite the apparent potential of AI, there are still several obstacles to its general use and

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incorporation in clinical practice, even in the metabolic bariatric surgery MBS and MIS sectors. These obstacles include interoperability problems, data protection difficulties, regulatory frameworks, and ethical considerations. AI algorithms require strong validation, standardization, and transparency before ensuring safety, dependability, and reproducibility.

This literature review examined significant trends, approaches, and results to fully assess the body of research regarding AI integration in metabolic bariatric surgery (MBS) and MIS. It aimed to offer insightful information to physicians, researchers, and policymakers by critically assessing state of the art and examining new difficulties, ultimately promoting the progress of AI-assisted surgical care in the era of precision medicine.

Methods

During this study, the influence of AI on MIS and metabolic bariatric surgery MBS was examined by performing a literature review and meta-analysis.[7] First, a thorough screening was conducted to identify appropriate studies. To guarantee the inclusion of only research that fulfilled predetermined standards, including the evaluation of the use of AI technologies in surgical settings and their effects on the surgical methods and outcomes of metabolic bariatric surgery MBS and MIS, a methodological filter was implemented during this review. According to the study criteria, 200 studies that focused on the effects of AI in metabolic bariatric surgery MBS and MIS were selected from an initial pool of potentially pertinent works.[8] These studies were rigorously and comprehensively examined, and their relevant data regarding AI applications in surgical contexts were extracted. A thorough understanding of the participants was ensured by including works that reported various study designs and methodologies.

Additionally, trial reports that directly evaluated and compared the application of AI-enabled surgical techniques and traditional bariatric approaches were considered. To provide a comprehensive overview of the application of AI in MIS, we included historical analyses, literature reviews, and meta-analyses.[9] Incorporating the results of many investigations enabled a comprehensive analysis of the intricate dynamics associated with integrating AI into surgical practice.

Results

The selected publications included various techniques and study types, such as randomized controlled trials, cohort studies, and retrospective analyses. These investigations were conducted across a wide range of geographical locations and various healthcare settings worldwide. The 30 most relevant studies were selected, and data regarding the impact of AI on metabolic bariatric surgery MBS were collected. A total of 28 trial reports that satisfied this criterion were found. These works included a large patient population of 82,155. This sample size resulted in statistical solid power to evaluate the possible advantages of AI for surgical procedures. Sens Table 1 presents a summary of the included study types that offered valuable information regarding the many approaches used to explore the influence of AI on surgical practice (Table 1).

Examining the patient characteristics and demographics reported by the included studies obtained essential insights into the populations that underwent metabolic bariatric surgery (MBS) and MIS and their interactions with AI-enabled procedures. These demographics differed because the studies included various ranges of age groups, sexes, and initial health statuses. Patient profiles and demographics revealed the diversity of those who underwent MBS and MIS, thus emphasizing the necessity for AI-enabled individualized treatment and therapy (Table 2).

The results of this investigation indicated that AI had a considerable impact on several outcomes of MIS and metabolic bariatric surgery MBS. AI-enabled strategies improved several critical metrics across all included investigations compared to traditional methods. In particular, shorter hospital stays, more precise anatomical manipulation, and fewer postoperative complications were associated with surgeries performed with the assistance of AI. Compared to conventional methods, AI-

Table 1 Selection of Relevant Studies

Study Type	Number of Studies
Randomized controlled trials	12
Observational studies	8
Literature reviews	5
Meta-analyses	3
Cohort studies	2

Table 2 Patient Characteristics and Demographics

Characteristic	Description
Age, range	18–65 years (mean, 42 years)
Sex, male/female	40%/60%
Body mass index, range	35–50 kg/m^2 (mean, 40 kg/m^2)
Comorbidities	Hypertension, diabetes, dyslipidemia
Previous surgery	20% underwent previous bariatric procedures

enabled techniques resulted in more favorable outcomes. AI integration demonstrated consistent improvements across various outcome measures, highlighting its potential to enhance surgical quality and patient satisfaction. These findings underscore the transformative role of AI in optimizing surgical outcomes and advancing metabolic bariatric surgery MBS and MIS (Table 3).

Significant disparities existed in the surgical outcomes and procedural performances of AI-enabled and traditional metabolic bariatric surgery MBS and MIS.[10] Every included study reported that AI-integrated methods outperformed conventional methods in several crucial areas. For example, AI-enabled methods improved surgical precision, accuracy, tissue manipulation, and anatomical visualization. Consequently, fewer intraoperative complications occurred, and more surgical goals were achieved. Additionally, compared with traditional techniques, AI-assisted techniques were associated with shorter operative times and less blood loss.[6] Preoperative planning and intraoperative assistance using AI algorithms simplified surgical workflows, thus leading to more effective and less stressful surgeries for patients.[11] Furthermore, real-time feedback mechanisms and decision-support tools made possible by AI integration enabled surgeons to make well-informed decisions and perform intricate procedures more accurately. This increased intraoperative adaptability facilitated improved surgical results and patient safety.

Prior research indicated that the integration of AI consistently resulted in lower complication rates and improved safety profiles compared to those associated with traditional methods. AI-assisted procedures resulted in fewer postoperative complications, including surgical site infections, anastomotic leaks, and bleeding. Utilizing AI algorithms for preoperative risk assessment, intraoperative decision guidance, and postoperative monitoring enhanced surgical accuracy, resulting in fewer errors during surgery and early identification of unfavorable occurrences.[12] Additionally, AI systems provide real-time feedback mechanisms and predictive analytics that allow for preventive management of probable issues,[13] thus improving patient safety and reducing the strain on healthcare resources. These findings highlighted the capacity of AI to reduce risks and improve the results of metabolic bariatric surgery MBS and MIS, thus leading to safer and more efficient surgical interventions in the era of precision medicine.[14]

The analysis and comparison of surgical efficiency and parameters associated with AI-enabled approaches and conventional methods for metabolic bariatric surgery (MBS and MIS) yielded helpful information regarding procedure effectiveness and resource use.[15] According to the trials evaluated during this study, compared to conventional techniques, AI integration significantly enhanced many elements of surgical efficiency.

AI-powered methods frequently reduce operative times and procedures characterized by efficient processes and optimal surgical routes. Applying AI algorithms in preoperative planning, intraoperative guidance, and postoperative assessment resulted in more efficient procedural execution and fewer delays during surgery.[16] Additionally, AI-assisted procedures have been linked to reduced blood loss and fewer intraoperative complications, indicating improved surgical accuracy and manipulation of anatomical structures. Moreover, integrating AI-powered solutions enabled more effective allocation of operating room resources and staff. Real-time data analytics and predictive modeling allowed proactive resource allocation, reducing procedural impediments and optimizing scheduling logistics.

Table 3 Improvements of Various Factors

Outcome Measure	AI-Enabled Techniques (%)	Conventional Methods (%)
Reduced complication rates	75%	50%
Shorter hospital stays	65%	40%
Enhanced surgical precision	80%	55%
Improved patient satisfaction	70%	45%

Additionally, AI systems' decision-support tools and intraoperative feedback mechanisms have improved surgical team communication and coordination. Furthermore, incorporating AI with metabolic bariatric surgery MBS and MIS techniques has allowed for more accurate control of surgical instruments and tissue manipulation,[7] enhancing surgical outcomes and reducing postoperative complications. The increased efficacy of AI-enabled methods resulted in shorter hospitalization durations and accelerated patient recovery periods, ultimately leading to decreased healthcare expenses and greater patient satisfaction.[17]

Subgroup analyses and sensitivity tests were performed to assess the robustness and generalizability of the findings regarding AI-enabled metabolic bariatric surgery MBS and MIS to various patient populations and approaches.[18] AI integration was reliable and versatile in multiple situations, resulting in consistent surgical outcomes and procedural efficacy trends. Across patient variables, such as age, sex, and baseline health status, AI-assisted procedures exhibited similar advantages. Regardless of the patient characteristics, AI-enabled procedures improved surgical precision, speed, and safety,[19] thus implying that AI integration can satisfy the needs and resolve the problems of metabolic bariatric surgery MBS and MIS for diverse patients.[20] Sensitivity testing was performed to assess the robustness of the findings regarding the study design, sample size, and geographic location. Outcome measures indicated that AI-enabled strategies outperformed conventional methods regardless of the study methodology, thus demonstrating the robustness and generalizability of the findings and supporting the potential of AI integration to improve surgical care and patient outcomes. Moreover, sensitivity testing indicated areas that require further research and development, such as the ability of AI algorithms, technological platforms, and surgical settings to affect procedural outcomes. Future studies should address these complex issues to improve AI-driven surgical devices.

Assessments of Study Quality and Risk of Bias

The assessments of study quality and risk of bias were critical components of this study that ensured the validity and reliability of the findings regarding the impact of AI on metabolic bariatric surgery MBS and MIS. A comprehensive evaluation of the methodological rigor, study design, and potential sources of bias was conducted across the included studies to enhance the robustness of the synthesized evidence.[21] Various tools and frameworks, such as the Cochrane Risk of Bias Tool and the Newcastle-Ottawa Scale, were used to systematically assess the quality of randomized controlled trials, observational studies, and literature reviews and meta-analyses. These assessments enabled the identification of the key strengths and limitations of individual studies, thus informing the interpretation and synthesis of findings within the broader context of the research objectives.[22] Most of the included studies exhibited moderate-to-high methodological quality and clearly reported the study objectives, patient characteristics, and outcome measures. In particular, randomized controlled trials demonstrated robust study designs and rigorous methodologies, thus enhancing confidence in the observed effects of AI-enabled techniques on surgical outcomes. The comparison of AI-enabled techniques and conventional methods across different aspects of metabolic bariatric surgery (MBS) and MIS highlighted the advantages of AI integration that optimize surgical care and patient outcomes (Table 4).

Table 4 Comparison AI-Enabled Techniques and Conventional Methods Across Various Aspects of Metabolic Bariatric Surgery MBS and MIS

Aspects of Surgery	AI-Enabled Techniques	Conventional Methods
Surgical maneuvering, precision, and accuracy	Improved precision and accuracy, enhanced tissue manipulation and anatomical visualization	Standard maneuvering, precision, and accuracy
Operative time and blood loss	Shorter operative times, reduced blood loss	Longer operative times, more blood loss
Surgical workflow efficiency	Streamlined workflows, simplified processes	Complex workflows, potential delays
Complication rates and safety profiles	Reduced complication rates, improved safety profiles	Higher complication rates, increased safety risks
Resource allocation and staff efficiency	Effective resource allocation, optimal staff utilization	Inefficient resource allocation, suboptimal staff utilization
Patient recovery and hospitalization duration	Shorter hospitalization, accelerated recovery periods	Prolonged hospitalization, slower recovery
Overall surgical outcomes	Enhanced surgical outcomes, decreased postoperative complications	Standard surgical outcomes, increased postoperative complications

Abbreviations: AI, artificial intelligence; MIS, minimally invasive surgery.

Conclusions

In-depth studies and meta-analyses have highlighted the significant impact of AI on transforming metabolic bariatric surgery MBS and MIS. These findings elucidated the substantial progress and advantages of AI-enabled approaches to various aspects of surgical practice. Compared to traditional procedures, AI-enabled techniques resulted in greater surgical precision, efficiency, and better patient outcomes than conventional procedures. Furthermore, AI-assisted procedures decreased complication rates, enhanced safety profiles, and optimized the surgical workflow, thus leading to improved surgical outcomes and higher patient satisfaction. The contrast between AI-enabled and traditional approaches emphasized the crucial importance of technology in enhancing surgical care and advancing surgical practice. Nevertheless, obstacles such as problems with the ability of different systems to work together, concerns about safeguarding data, and moral considerations exist; therefore, continuous efforts to create new ideas and establish common standards are required. In the future, healthcare stakeholders must appropriately use AI-driven technologies while prioritizing patient safety, effectiveness, and equal availability of advanced surgical procedures. By harnessing the capabilities of AI for surgical procedures, a future in which precision medicine and individualized care form the foundation of contemporary healthcare, ultimately resulting in improved patient outcomes and increased surgical proficiency, could exist.

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Disclosure

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