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ARTIFICIAL INTELLIGENCE–BASED PREDICTIVE MODELING FOR SURGICAL PLANNING IN DECOMPENSATED COLOSTASIS

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Abstract

Decompensated colostasis is a life-threatening condition characterized by severe intestinal obstruction, ischemic changes, and risk of perforation. Determining the appropriate extent of colon resection remains a major surgical challenge. Artificial intelligence (AI) has emerged as a powerful tool for improving preoperative planning through predictive modeling and large-scale clinical data analysis. This study explores the application of AI-based systems in predicting tissue viability, defining resection margins, and estimating postoperative complication risks in patients with decompensated colostasis. The integration of AI into surgical decision-making may enhance operative precision, reduce unnecessary resections, and improve patient outcomes.

Keywords: artificial intelligence, predictive modeling, colon resection, decompensated colostasis, surgical planning, machine learning.

Introduction

Decompensated colostasis represents an advanced stage of colonic obstruction associated with impaired motility, progressive bowel dilation, ischemia, and systemic inflammatory response. Emergency surgical intervention is often required to prevent perforation, sepsis, and multi-organ failure. One of the critical aspects of operative management is accurate determination of the resection volume.

Conventional diagnostic tools such as computed tomography (CT), laboratory inflammatory markers, and intraoperative visual assessment provide important information but may not fully capture the complexity of tissue viability and microvascular perfusion. Inaccurate estimation of resection margins may lead either to insufficient removal of compromised bowel segments or excessive resection, resulting in increased morbidity.

Artificial intelligence offers advanced analytical capabilities through machine learning and deep learning technologies. By integrating imaging, laboratory, and clinical data, AI systems can support objective and data-driven surgical planning.

Objective

The objective of this study is to evaluate the effectiveness of artificial intelligence–based predictive modeling in determining the optimal volume of colon resection in patients with decompensated colostasis and to assess its impact on surgical accuracy and postoperative outcomes.

Methods

This research was conducted as a retrospective analytical study combined with computational modeling. Clinical and radiological data from patients diagnosed with decompensated colostasis were analyzed. Parameters included CT imaging findings, colon wall thickness, bowel diameter, perfusion patterns, inflammatory markers, duration of obstruction, and comorbidities.

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Machine learning algorithms were developed to analyze structured datasets and identify predictive variables associated with bowel necrosis, ischemia progression, and postoperative complications. Deep learning models were applied to contrast-enhanced CT scans to perform automated segmentation and detection of compromised tissue zones.

Predictive models were trained using supervised learning techniques and validated through cross-validation methods. Performance metrics included sensitivity, specificity, predictive accuracy, and area under the receiver operating characteristic curve (AUC). Comparative evaluation was performed between AI-supported planning and conventional surgical assessment.

Results

The analysis demonstrated that AI-based predictive modeling improved the accuracy of preoperative estimation of resection margins. Deep learning image segmentation identified ischemic zones with high precision, allowing for more accurate boundary determination compared to visual radiological interpretation alone.

Predictive algorithms effectively stratified patients according to complication risk, including anastomotic leakage and postoperative infection. AI-assisted planning reduced intraoperative adjustments of resection margins and decreased operative time in simulated evaluations.

Furthermore, AI systems identified complex data correlations between inflammatory markers, perfusion deficits, and structural bowel changes, which were not consistently recognized using standard diagnostic methods. These findings highlight the ability of AI to detect subtle pathological patterns through large-scale data processing.

Literature Review

The rapid development of artificial intelligence (AI) technologies has significantly influenced modern surgical practice, particularly in diagnostic imaging and preoperative planning. Numerous studies emphasize the transformative potential of AI in medicine, highlighting its ability to process large datasets, identify complex patterns, and enhance clinical decision-making.

Esteva et al. (2019) and Topol (2019) describe AI as a key component of precision medicine, capable of integrating clinical, imaging, and laboratory data to support individualized treatment strategies. Their work underscores the importance of combining human expertise with algorithmic analysis to improve healthcare outcomes. In surgical disciplines, this integration has become particularly relevant for complex decision-making processes.

Hashimoto et al. (2018) and Maier-Hein et al. (2017) introduced the concept of surgical data science, emphasizing that AI-driven analytics can optimize intraoperative decision-making and improve procedural accuracy. They argue that advanced computational models can assist surgeons by reducing variability and enhancing predictive capabilities. These principles are directly applicable to colorectal surgery, where determining resection boundaries requires precise evaluation of tissue viability and disease extent.

In the field of medical imaging, Litjens et al. (2017) and Park & Han (2018) demonstrated the effectiveness of deep learning models, particularly convolutional neural networks, in analyzing radiological data. Their findings show that AI-based imaging systems can detect subtle pathological features that may be overlooked in conventional interpretation. This capability is crucial in decompensated colostasis, where ischemic and inflammatory changes may not always be clearly distinguishable.

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Specific to colorectal surgery, Kather et al. (2019) and Kitaguchi et al. (2020) explored the application of AI in predicting tumor behavior and supporting surgical decisions. Their studies reveal that AI algorithms can accurately assess tissue characteristics and predict clinical outcomes, thereby facilitating more precise surgical planning. Similarly, Damián et al. (2020) reviewed current AI applications in colorectal surgery and concluded that predictive modeling improves risk stratification and perioperative management.

Collins et al. (2015) emphasized the importance of transparent reporting in predictive modeling, highlighting methodological standards necessary for clinical implementation. Meanwhile, Kelly et al. (2019) discussed the challenges associated with translating AI innovations into routine practice, including validation, data quality, and ethical concerns.

Collectively, the reviewed literature confirms that artificial intelligence provides substantial advantages in preoperative diagnostics and surgical planning. By analyzing multidimensional clinical data and identifying complex correlations, AI systems enhance accuracy in determining resection volume and predicting postoperative complications. However, further prospective validation and integration into clinical workflows remain essential for widespread adoption.

Overall, the existing scientific evidence supports the innovative role of artificial intelligence in optimizing colorectal surgical management, particularly in complex conditions such as decompensated colostasis.

Discussion

Artificial intelligence introduces a novel paradigm in surgical planning for decompensated colostasis by transforming heterogeneous clinical data into actionable predictive insights. The ability to analyze multidimensional datasets enhances diagnostic precision and supports evidence-based surgical decision-making.

AI-driven prediction of tissue viability and complication risk may reduce both under-resection and over-resection. By providing objective calculations of resection boundaries, AI contributes to improved safety and individualized operative strategies.

However, successful clinical implementation requires robust validation, standardized data collection protocols, and integration with hospital information systems. Ethical considerations and transparency of algorithm decision-making processes must also be addressed to ensure clinician trust and patient safety.

Conclusion

Artificial intelligence–based predictive modeling represents a promising advancement in the surgical management of decompensated colostasis. By enabling precise assessment of tissue viability and optimal resection volume, AI enhances preoperative planning and supports safer, more individualized surgical interventions.

Future prospective clinical studies are required to validate these findings and establish AI as a routine tool in colorectal surgical practice. The integration of artificial intelligence into surgical workflows may significantly improve outcomes and reduce complications in patients with severe colonic obstruction.

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