Chapter 3

ACUTE INTESTINAL OBSTRUCTION: ARTIFICIAL INTELLIGENCE IN DIAGNOSTICS, PREDICTIVE ANALYTICS AND TREATMENT

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INTRODUCTION

Acute intestinal obstruction (AIO) is one of the most serious acute diseases in abdominal surgery due to the peculiarities of the course of clinical manifestations, the difficulties of diagnosis, a significant number of complications and high postoperative mortality. In the 21st century, artificial intelligence began to be rapidly introduced into almost all areas of science and technology. Medicine was no exception and artificial intelligence began to be used in various fields of diagnosis, treatment and rehabilitation of patients with various diseases. Artificial intelligence (AI) can be incredibly valuable in the diagnosis and treatment of acute mesenteric ischemia (AMI), serious condition that require prompt intervention to prevent bowel necrosis and other severe complications.

AI-based monitoring systems can continuously analyze patient data to detect early signs of malignant bowel obstruction recurrence or treatment complications, enabling prompt intervention. AI algorithms can analyze various imaging modalities such as CT scans, X-rays, or ultrasound to detect signs of malignant and nonmalignant intestinal obstructions. AI-powered decision support systems can integrate patient data such as medical history, physical examination findings, laboratory results, and imaging findings to assist clinicians in diagnosing nonmalignant intestinal obstruction and selecting appropriate treatment strategies.

Predictive analytics for assessing the risk of complications such as bowel ischemia or perforation in patients with AIO have been employed to analyze patient data and predict the likelihood of these complications, aiding clinicians in early intervention and improved patient management.

1. Historical aspects of diagnosis and treatment of acute intestinal obstruction

The diagnosis and treatment of acute intestinal obstruction (AIO) has evolved significantly over the centuries, reflecting extensive changes in medical knowledge, technology, and surgical techniques.

Already in Antiquity and the Middle Ages, states that can be interpreted as intestinal obstruction are mentioned, but detailed knowledge was very limited. One of the most important medical texts of ancient Egypt is the Ebers Papyrus, which dates to about 1550 BC. This papyrus is one of the oldest known surviving manuscripts and, in particular, medical texts. It contains information on the treatment of a variety of conditions, including constipation, hemorrhoids, and eye conditions. The Ebers Papyrus also mentioned bowel disorders with symptoms similar to obstruction[1]. Often called the "father of medicine," Hippocrates (ca. 460–370 BC) and his followers described various abdominal ailments, although their understanding of intestinal obstruction was rudimentary. They recommended dietary changes and laxatives as treatment. Galen (129–216 AD), a Roman physician and philosopher whose many writings included observations on diseases of the abdominal cavity, suggested that intestinal obstruction could result from a variety of causes, including physical blockages and functional problems. Treatment was still limited to non-surgical interventions[2].

The Renaissance saw a significant surge in anatomical knowledge thanks to figures such as Andreas Vesalius (1514–1564). Improved understanding of human anatomy laid the foundation for more effective surgical approaches to treating intestinal obstruction, although interventions remained risky and often a last resort.

Since the beginning of surgical interventions for intestinal obstruction, in the 18th and 19th centuries, there have been dangerous times for patients due to the high risk of infection and the lack of effective anesthesia and antiseptics. The development of X-ray technology in the late 19th and early 20th centuries revolutionized the diagnosis of intestinal obstruction. For the first time, doctors could directly visualize the causes of intestinal obstruction[3].

The advent of antibiotics and advances in anesthesia in the first half of the 20th century greatly reduced the risks associated with abdominal surgery, making surgery a more viable treatment option for intestinal obstruction[4].

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[1] Wikipedia, URL: https://uk.wikipedia.org/wiki / The Ebers Papyrus.

[2] A Perfect Work of God: Galen on the Usefulness of the Parts of the Body. Cornell University Press, Ithaca, N. Y., 1968. 2 vols., Vol 163, Issue 3874, DOI: 10.1126/science.163.3874.1439804 pp.

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[4] Owen H. Wangensteen et Sarah D. Wangensteen, The Rise of Surgery. From Empiric Craft to Scientific Discipline – 1980 – Review d' History des Sciences 33 (4):375-376.

Laparoscopic surgery: at the end of the 20th century, laparoscopic methods were introduced that allow for minimally invasive operations on various organs of the abdominal cavity: gall bladder, pancreas, stomach and intestines. This approach has reduced complications and recovery time for patients undergoing surgery for intestinal obstruction.[5],[6],[7]

Multimodal treatment is a modern method of treating AIO and involves a combination of diagnostic imaging (ultrasound, X-ray, CT, MRI), medical treatment (resuscitation, intensive care, antibiotics) and surgical intervention, if necessary. The decision-making process is guided by the cause of the obstruction (mechanical or functional), the location, and the general condition of the patient. For certain types of obstructions, especially those that are partial or caused by certain diseases, such as Crohn's disease, nonoperative treatment has become more effective. The use of multimodal tactics of surgical treatment of patients with AIO ensures a reduction in the frequency of postoperative complications. Advanced and innovative imaging techniques, such as high-resolution CT and MRI, have improved the accuracy of diagnosing intestinal obstruction. The introduction of minimally invasive and robotic surgery offers even greater surgical precision, potentially improving outcomes for patients with intestinal obstruction.

2. Artificial intelligence in diagnoses, predictive analytics and treatment of acute intestinal obstruction

In the 21st century, artificial intelligence began to be rapidly introduced into almost all areas of science and technology. Medicine was no exception and artificial intelligence began to be used in various fields of diagnosis, treatment and rehabilitation of patients with various diseases. Artificial intelligence (AI) can be incredibly valuable in the diagnosis and treatment of acute mesenteric ischemia (AMI) and ischemic colitis (IC), serious conditions that require prompt intervention to prevent bowel necrosis and other severe complications. AI algorithms can analyze medical imaging scans such as CT scans, MRIs, or angiograms to detect signs of AMI and IC.[8],[9] These algorithms can identify features such as narrowing or occlusion of mesenteric

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arteries, bowel wall thickening, pneumatosis intestinalis, or portal venous gas, which are indicative of AMI, and they can also identify features such as mucosal edema, bowel wall thickening, segmental colonic dilation, or pneumatosis, which are indicative of ischemic colitis. For differential diagnosis of AMI can be used deep learning algorithms, particularly Convolutional neural networks (CNNs), that can be trained on large datasets of annotated medical images to accurately detect these features and assist radiologists in making timely diagnoses. Convolutional networks have also been applied in drug discovery. They aid in identifying potential treatments by analyzing interactions between molecules and biological proteins. These systems can use machine learning algorithms to analyze complex patterns in patient data and provide recommendations for further diagnostic evaluation or treatment options.[10],[11]

AI models can help stratify patients based on their risk of developing AMI or experiencing complications following diagnosis. By analyzing a combination of demographic data, comorbidities, clinical symptoms, and laboratory results, AI algorithms can identify high-risk patients who may benefit from continuing close monitoring or early surgical intervention. AI can assist in optimizing treatment strategies for patients with AMI or IC. For example, machine learning algorithms can analyze clinical data to predict individual patient responses to different treatment modalities, such as methods of surgical revascularization, endovascular interventions and medical management. AI-powered predictive analytics can help to identify the most effective treatment approach for each patient, considering factors such as disease severity, comorbidities, and anticipated outcomes.

AI-based monitoring systems can continuously monitor patient data in real-time to detect early signs of AMI recurrence or complications. AI can accelerate clinical research efforts in the field of AMI by enabling the analysis of large-scale patient data to uncover new insights into disease mechanisms, prognostic factors, and treatment outcomes. Machine learning algorithms can analyze clinical data to predict the likelihood of complications such as bowel ischemia or perforation in patients with acute intestinal obstruction. This can help guide treatment decisions and optimize patient management.[12]

AI-driven approaches such as natural language processing (NLP) can also facilitate the extraction and analysis of valuable information from medical

[10] Loussaief S., Abdelkrim A. "Machine learning framework for image classification," 7th International Conference on Sciences of Electronics, Technologies of Information and Telecommunications (SETIT), Hammamet, 2016, pp. 58-61, URL: https://doi.org/10.1109/SETIT.2016.7939841

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literature, electronic health records, and other sources to support evidence-based practice and guideline development. AI can assist in optimizing treatment strategies for acute intestinal obstruction by analyzing clinical data to predict individual patient responses to different treatment modalities, such as conservative management, nasogastric decompression, or surgical intervention.[13]

The integration of AI into the diagnosis and treatment of acute mesenteric ischemia has the potential to improve clinical outcomes, enhance efficiency, and optimize resource utilization in healthcare settings. However, it's essential to ensure that AI tools are rigorously validated, ethically deployed, and seamlessly integrated into existing clinical workflows to maximize their benefits for patients and healthcare providers.

AI-based monitoring systems can continuously analyze patient data to detect early signs of septic complications or treatment failure in patients, allowing for timely surgical and intensive care intervention.[14]

AI can facilitate clinical research in the field of acute intestinal obstruction by enabling the analysis of large-scale patient data to uncover new insights into disease mechanisms, prognostic factors, and treatment outcomes.[15]

Diagnosing and treatment acute intestinal obstruction of malignant origin can benefit from various applications of artificial intelligence (AI). Diagnosing and treating acute intestinal obstruction of malignant origin can benefit from various applications of AI. AI algorithms can analyze radiological images such as CT scans, MRI scans, or PET scans to identify features indicative of malignant intestinal obstruction, such as tumor masses, bowel wall thickening, or peritoneal metastases.[16],[17]

AI-powered decision support systems can integrate patient data, including clinical history, laboratory results, imaging findings, and tumor markers, to aid clinicians in diagnosing malignant intestinal obstruction and selecting appropriate treatment options.[18],[19] Machine learning models can predict the

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risk of malignant bowel obstruction as diagnosis and chances of recurrency and complications based on patient-specific factors, helping in planning of tailor treatment strategies and surveillance plans.[20],[21] In a next study authors developed a risk stratification model using machine learning techniques to predict adverse outcomes in patients with small bowel obstruction. The model integrated clinical and radiological variables to identify high-risk patients who may require more aggressive management.[22]

AIO complications with bowel necrosis, peritonitis and sepsis can be a deadly condition that develops as a result of infection developing quickly. Therefore, predictive analytics can be key in early detection and interventions. Predictive algorithms help in determining patients who are most likely to develop sepsis by continuously monitoring patients' vital signs and other vital data.

Next study investigated the impact of a structured preoperative risk score, incorporating machine learning algorithms, on the incidence of major complications after emergency general surgery procedures, including those related to acute intestinal obstruction. The risk score helped identify patients at higher risk of complications, facilitating proactive management strategies. These studies demonstrate the potential of predictive analytics, coupled with machine learning techniques, in assessing the risk of complications in patients with acute intestinal obstruction, thereby enabling clinicians to intervene early and improve patient outcomes. AI can assist in optimizing treatment approaches for malignant intestinal obstruction by analyzing patient data and predicting responses to various treatment modalities, such as surgery, chemotherapy, or palliative care.[23],[24]

AI-based monitoring systems can continuously analyze patient data to detect early signs of malignant bowel obstruction recurrence or treatment complications, enabling prompt intervention. AI algorithms can analyze various imaging modalities such as CT scans, X-rays, or ultrasound to detect signs of nonmalignant intestinal obstruction. These algorithms can identify features such as dilated loops of bowel, air-fluid levels, or the presence of

[20] Moore, G., & Cunningham, C. (2019). Predictive analytics: Harnessing the power of big data. IEEE transactions on emerging topics in computing, 7(2), 292-303.

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hernias or adhesions.[25],[26],[27] Decision support systems can integrate medical history, physical examination, laboratory results, and imaging findings to assist clinicians in diagnosing nonmalignant intestinal obstruction and selecting appropriate treatment strategies.[28],[29] AI can assist in optimizing treatment approaches for nonmalignant intestinal obstruction by analyzing patient data and predicting responses to different treatment modalities, such as bowel decompression, fluid resuscitation, or surgical intervention.

CONCLUSIONS

The results of using artificial intelligence (AI) for the diagnosis and treatment of acute intestinal obstruction, whether of malignant or nonmalignant origin, have shown promising outcomes in various studies. AI algorithms have demonstrated high accuracy in detecting signs of intestinal obstruction on medical imaging studies, leading to more accurate and timely diagnoses. AI-based decision support systems have helped clinicians in selecting optimal treatment strategies for acute intestinal obstruction by analyzing patient data and predicting treatment responses

Machine learning models have been successful in predicting the risk of complications, such as bowel ischemia or perforation, in patients with acute intestinal obstruction, aiding in early intervention and improved patient outcomes.

These findings underscore the potential of AI to improve the diagnosis and treatment of acute intestinal obstruction, irrespective of its underlying cause, by enhancing diagnostic accuracy, treatment planning, predictive analytics, real-time monitoring, and ultimately patient outcomes.

SUMMARY

Acute intestinal obstruction (AIO) is one of the most serious acute diseases in abdominal surgery due to the peculiarities of the course of clinical manifestations, the difficulties of diagnosis, a significant number of complications and high postoperative mortality. In the 21st century, artificial intelligence began to be rapidly introduced into almost all areas of science and technology. Medicine was no exception and artificial intelligence began to be

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