RESEARCH ARTICLE

Impact of New Technologies and Artificial Intelligence on the Optimization of Enhanced Recovery Protocols in Urology

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ABSTRACT

Introduction and Objective: The approach of Enhanced Recovery after Surgery represents a contemporary paradigm in surgical development. It has proven to improve postoperative parameters. It has become the standard in the management of major surgery. The objective is to perform a literature review on the integration and impact of artificial intelligence and robotic surgery on the enhanced recovery after surgery system.

Materials and Methods: This is a recent literature review conducted on research platforms such as PubMed, Cochrane, and Scholar. It is a review that focuses on the last ten years, from 2014 to 2024. An estimated 17 articles were included in this work using the following keywords: Enhanced Recovery after Surgery protocol, Artificial intelligence, robotic surgery, and urology.

Results: Three major therapeutic advances have positively impacted the application of the enhanced recovery after surgery protocol: Robotic surgery and telesurgery, telemedicine, and artificial intelligence. These new technologies significantly reduce postoperative complications and shorten patient recovery. Enhanced recovery after surgery protocols in robotic urological surgery are associated with improved recovery and resource utilization. All urological procedures can be performed by robotic surgery and sometimes even with robotic telesurgery, which currently requires validation by scientific institutions. The integration of artificial intelligence and new technologies into enhanced recovery after surgery protocols offers significant opportunities to address implementation challenges and improve patient care. Artificial intelligence-based technologies require a large database. Ideally, all platforms should be unified into a single database with a single medical record to create a valid and efficient clinical decision support system.

Conclusion: The integration of artificial intelligence and robotic surgery has become mandatory in the enhanced recovery after surgery system. New technologies offer optimization and personalization of the protocol by simplifying clinical plans, ensuring high compliance, and creating patient-centered approaches with improved clinical outcomes and patient satisfaction.

Keywords: Enhanced recovery after surgery protocol, artificial intelligence, robotic surgery, urology

1. Introduction

The approach of Enhanced Recovery after Surgery represents a contemporary paradigm in surgical development, by means of multidisciplinary collaboration among surgery, anaesthesia, nutrition, and nursing. It optimizes perioperative clinical pathways based on evidence-based principles. By alleviating various perioperative stress responses, the protocol aims to reduce hospital stays, decrease postoperative complications, and promote recovery[1]. Currently, the protocol contains three groups of items containing seven variables: the preoperative phase, the intraoperative phase, and the postoperative phase. It is based on several parameters: patient-centeredness, minimally invasive surgery, and multi-professional care[2].

Several difficulties hinder the effective implementation of the Enhanced Recovery After Surgery protocol. Resistance to change from established practices, a lack of time and personnel resources, can impede the effective implementation of these protocols. To overcome these challenges, the new technologies and artificial intelligence can help establish a well-trained multidisciplinary team, improving communication and facilitating regular audits and feedback mechanisms to monitor progress and motivate staff. Artificial intelligence technologies can improve adherence to the enhanced recovery after surgery protocols by simplifying clinical plans and ensuring high compliance[3,4] .

Three major therapeutic advances have positively impacted the application of the Enhanced recovery after surgery protocol: Robotic surgery and telesurgery, Telemedicine, and Artificial intelligence. These new technologies significantly reduce postoperative complications and shorten patient recovery.

This work aims to review the modern literature in order to highlight the impact and effectiveness of new technologies and artificial intelligence on the use of the Enhanced Recovery After Surgery protocol.

2. The Items of the Enhanced Recovery After Surgery Protocol Applied in Urology:

Three groups of items containing seven variables: the preoperative phase, the intraoperative phase, and the postoperative phase.

The parameters of the preoperative phase are patient education and information, optimization of organ dysfunction (smoking cessation), mechanical bowel preparation, carbohydrate drink, pre-anesthetic sedative medications, thromboembolic prophylaxis, preoperative fasting, and patient nutritional status.

The parameters of the intraoperative phase are epidural analgesia, minimally invasive approach, surgical site drainage, antimicrobial prophylaxis, fluid management, and hypothermia prevention.

The postoperative phase parameters are nasogastric intubation, prevention of ileus, prevention of nausea and vomiting, postoperative analgesia, early mobilization, and early oral feeding[5,6].

3. Robotic Surgery and the Minimally Invasive Approach:

Enhanced recovery after surgery protocols in robotic urological surgery are associated with improved recovery and resource use. In robot-assisted prostatectomy, studies report that time to first defecation shortened, hospital stays decreased, lower postoperative pain, and opioid consumption fell from 46 to 15 morphine milligram equivalents. In other series, length of stay decreased, and opioid use declined [7,8].

Postoperative complications and hospital length of stay decreased for robotic-assisted radical cystectomy patients with an enhanced recovery after surgery protocol, improvement in prognosis and outcome in the high adherence to the protocol group compared to the low adherence group. Reported secondary outcomes include faster milestones such as earlier ambulation, flatus, drain removal, and improved pain control without increased risks.

Enhanced recovery after surgery strategies varied among studies; several detailed components, such as multimodal analgesia and nutritional support, while others did not specify protocol elements. The evidence from these reports shows that, across diverse robotic urological procedures, enhanced recovery after surgery protocol implementation coincides with accelerated recovery and enhanced perioperative efficiency[9,10].

4. Telemedicine and Telesurgery:

Telemedicine is now reported as a successful means within the anesthetic pathway, including consultations, preoperative evaluation, and remote patient monitoring. Telemedicine for the intensive care unit is associated with better outcomes, and it can significantly improve intensive care unit survival, hospital mortality, and shorten the length of stay in the intensive care unit. The telemedicine allows post-operative virtual visits to be carried out to offer a complete and precise education pathway and to avoid the need for patients to travel to hospital structures[11,12].

Postoperative pain management is an important element in the enhanced recovery after surgery protocol. It is based on reducing the dose of opioids. This management could be managed outside the hospital thanks to artificial intelligence algorithms and patient feedback via teleconsultation[13].

Robotic telesurgery has revolutionized laparoscopic surgery and generated a major development in patient care. Several robotic platforms have adopted this telesurgery system approved by the Food and Drug Administration and Conformité Européenne. Among surgical specialties, urology has stood out by adopting this technique quickly. Despite the advances in telesurgery, access to this resource remains limited. However, it could generate many benefits for the world's population, especially for remote areas where specialized medical services are not available[14,15].

5. Artificial Intelligence for Personalized Enhanced Recovery after Surgery protocol:

The development of artificial intelligence is disruptive and unstoppable in medicine. Recently, research has focused on the development of artificial intelligence and its use in the application of enhanced recovery after surgery protocol management. The ultimate goal of this technology is to facilitate the application of the protocol, offer personalized care by stratifying patient risk, and develop mobile applications based on chatbots in order to establish permanent education, feedback, and interactive communication for the patient[16,17.]

5.1 MACHINE LEARNING ALGORITHMS:

These are decision support tools that predict the risk of complications for each patient by analyzing data contained in the electronic medical record. Preoperatively, risk stratification is a difficult but critical process for making personalized management decisions. The importance of risk stratification lies in its role in optimizing clinical outcomes and preventing potential complications. The MySurgeryRisk in 2020 machine learning algorithm, created by Bihorac et al., was validated to predict postoperative complications and mortality after an analysis of 50,000 procedures. This algorithm demonstrated high sensitivity and specificity for predicting acute kidney injury, sepsis, and neurological and cardiovascular complications[18,19].

Intraoperatively, machine learning algorithms allow for the regulation of general anesthesia levels in real time by adapting drug doses delivered based on the algorithm's predictive awakening factors to avoid human error. Wang et al. demonstrated that the convolutional neural network algorithm adjusts the administration of agents based on monitor variables to maintain a stable general anesthesia level. This artificial intelligence-based approach has proven superior to the conventional approach[20].

5.2 CLINICAL DECISION SUPPORT SYSTEM:

These are predictive decision support tools that allow for the analysis and comparison of patient data based on medical records. According to Francis et al. in colorectal surgery, the artificial neural network model can predict the readmission rate and delayed discharge rate for each patient based on predictive factors. This system improves resource utilization and provides personalized care[21].

In postoperative settings, artificial intelligence-driven predictive models and clinical decision support systems play a pivotal role, aiding in the selection of the most appropriate post-operative in-hospital setting, determining optimal discharge timing, and tailoring post-discharge monitoring strategies[22].

6. New Technologies Inserted:

These are chips inserted or worn by patients preoperatively, which allow the collection of patient health data and offer pre-habilitation and personalized monitoring. They can improve risk stratification and adapt medical treatment to prevent complications[23].

6.1 ARTIFICIAL INTELLIGENCE-ASSISTED NAVIGATION SYSTEMS:

These are navigation systems used by both surgeons and anesthesiologists to increase the efficiency and feasibility of procedures. The adoption of artificial intelligence-guided regional anesthesia could encourage the widespread adoption of this practice and provide multimodal pain management, and reduce opioid dependence, which is a key component of the Enhanced recovery after surgery protocol.

Intraoperative navigation systems in surgery and specifically in urology are three-dimensional-segmented virtual reality, endoscopic tracking by markers, and puncture assisted by markers and an iPad. These procedures are used in several urological interventions to reduce positive margins and the reproducibility of the operative gesture. During a radical prostatectomy or partial nephrectomy, endoscopic tracking by markers or augmented reality significantly helps to reduce positive margins. During a renal biopsy or puncture for a percutaneous nephrolithotomy, puncture assisted by markers and an iPad is necessary at the beginning of experience to avoid any trauma[17].

6.2 ARTIFICIAL INTELLIGENCE-GUIDED REAL-TIME MONITORING WEARING DEVICES:

Enhanced recovery after surgery protocols promote early discharge to home even after major surgery. This is possible unless home surveillance is provided. Real-time patient-worn monitoring devices coupled with artificial intelligence systems can track the patient's vital signs and physical activity to detect abnormalities and serious adverse events for possible readmission or home treatment. This approach has demonstrated its potential to reduce intensive care unit admissions, complications, mortality, and hospital stays[24].

7. The Challenges of Using Artificial Intelligence in the Enhanced Recovery after Surgery Protocol:

Patient data is often fragmented across different platforms. Ideally, all platforms should be unified into a single database to create a valid and efficient clinical decision support system.

Given that these technologies require the creation of large data sets, the issue of cybersecurity and how to protect these systems is a must before these models can be widely adopted.

The integration of these technologies into routine clinical practice remains expensive. It requires a complete and comprehensive electronic medical record. Although the economic cost of incorporating artificial intelligence into information systems remains uncertain, several studies have demonstrated economic gains by reducing hospital stays, complications, and painkiller use[25].

Conclusion

Artificial intelligence can play a crucial and essential role in overcoming challenges in Enhanced Recovery after Surgery implementation by simplifying clinical plans, ensuring high compliance, and creating patient-centered approaches. The integration of artificial intelligence and robotic surgery has become mandatory in the Enhanced recovery after surgery system. New technologies offer optimization and personalization of the protocol by simplifying clinical plans, ensuring high compliance, and creating patient-centered approaches with improved clinical outcomes and patient satisfaction. Although challenges exist, such as the use of large databases, the unification of electronic medical records, the generalization of virtual reality algorithms across all robotic platforms and encouraging teleconsulting in all phases of the Enhanced Recovery after Surgery protocol. With all these challenges, all authors prove that artificial intelligence and new technologies improve the results of the Enhanced Recovery after Surgery protocol and that artificial intelligence will become in the near future a standard of the protocol in surgery and urology.

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