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Optimized Anesthesia and Analgesic Regimen for Robotic Colorectal Surgery

Lars P H Andersen[1*], **Egon G Hansen**[2], **Ismail Gögenur**[1] **and Jacob Rosenberg**[1]

[1]*Department of Surgery, Herlev Hospital, University of Copenhagen, DK-2730 Herlev, Denmark*

[2]*Department of Anesthesiology, Herlev Hospital, University of Copenhagen, DK-2730 Herlev, Denmark*

[*]**Corresponding author:** Lars Peter Holst Andersen, Department of Surgery, Herlev Hospital, University of Copenhagen, DK-2730 Herlev, Denmark, Tel: +45 31518908; Fax: +45 38683602; E-mail: lphandersen@gmail.com

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Abstract

Robotic surgery has recently been introduced for colorectal procedures. In robotic colorectal surgery, only a few low-powered randomized studies have been performed, demonstrating equal short-term surgical outcomes. Robotic surgery offers specific technical advantages; however, studies have documented increased operative time and economic costs compared to both open and laparoscopic colorectal surgery. At the moment, no randomized studies, cohort studies or case-series have investigated outcomes related to anesthesia or analgesic treatment in robotic colorectal surgery. Experience and transferable evidence from laparoscopy and other fields of robotic surgery, such as urology and gynecology may provide valuable information when introducing this new technique. This review presents an overview of the anesthesiological challenges during robotic colorectal surgery. Furthermore, clinical recommendations are presented in relation to patient preparation, patient safety, anesthetic treatment, and postoperative pain management.

This review recommends total intravenous anesthesia, including propofol and ultra-fast acting opioids. Moreover, neuromuscular blocking agents for complete (deep) block are mandatory. For postoperative analgesic treatment, a multimodal regimen including dexamethasone, paracetamol, COX-1selective NSAIDs, oral opioids is recommended. Clinical effects and the administration routes of local anesthetics must be investigated further. In general, focus of the clinician should be drawn towards the preparation phase before surgery and knowledge of the physiological changes and patient handling in relation to Trendelenburg positioning and pneumoperitoneum. Lessons learned from laparoscopic colorectal surgery can be applied with respect to anesthetic- and postoperative analgesic treatment until further evidence is provided.

Keywords: Robotic surgery; Neuromuscular blocking agents; Trendelenburg positioning; Pneumoperitoneum

Introduction

Robotic surgery has recently been introduced for colorectal procedures [1]. The Da Vinci surgical system is currently the only FDA-approved robotic device in clinical practice. The transition from open to laparoscopic technique has documented improved perioperative- and comparable long-term outcomes in colorectal surgery [2-4]. In robotic colorectal surgery, only a few low-powered randomized studies have been performed, demonstrating equal short-term surgical outcomes [5-7].

Robotic surgery offers specific technical advantages such as magnified three-dimensional view and wristed surgical instruments, which may improve accurate tissue dissection and potentially patient outcome. On the other hand, studies have documented increased operative time and a substantial increase in economic costs compared to both open and laparoscopic colorectal surgery [8].

As in all types of surgery, robotic colorectal surgery requires anesthesiological considerations, which should be addressed in order to increase the safety of surgical procedure. At the moment, no randomized studies have investigated outcomes related to anesthesia or analgesic treatment in robotic colorectal surgery. Moreover, none of the large number of cohort studies or case-series has described anesthetic treatment or postoperative pain management in sufficient detail to provide any solid evidence concerning this patient category. However, robotic surgery can be considered as an advanced laparoscopic procedure, and therefore, until clinical trials have been performed, experience and transferable evidence from laparoscopy and other fields of robotic surgery, such as urology and gynecology can provide valuable information when introducing this new technique.

This review presents an overview of the anesthesiological challenges during robotic colorectal surgery. Furthermore, clinical recommendations are presented in relation to patient preparation, patient safety, anesthetic treatment and postoperative pain management.

Preparation of the Patient

Robotic surgery requires careful preparation in the operating room due to patient arms placed alongside the body, the extensive and non-movable nature of the robot and a face protection shield [9]. Patient access is limited during surgery, and venous cannulas, tubes and patient monitoring equipment must therefore be properly secured in the preparation phase. Moreover, robotic colorectal surgery, as well as laparoscopy, is often performed in Trendelenburg position [10]. However, the combined effects of a more "fixed" Trendelenburg position and the extended duration of robotic surgery, require further attention to correct positioning of the patient to reduce the risk of pressure ulcers, nerve damage and compartment syndrome [11-14].

Furthermore, the "secured" positioning is also required to avoid the deleterious effects of patient sliding during the "docked" surgical procedure.

Safety during cardiac arrest and rapid surgical conversion

Docking of the robot reduces the immediate access to the patient in surgical or medical emergencies. Incidents, such as massive bleeding or cardiac arrest require rapid access to the patient [15,16]. The Da Vinci system can be undocked in less than 15 seconds when needed. However, it is mandatory that the whole operating team is aware of emergency protocols to ensure patient safety.

Physiological changes during robotic surgery

Robotic colorectal surgery induces several physiological changes in function due to the combined effects of Trendelenburg position and pneumoperitoneum. No studies have investigated the clinical impact of these physiological changes in relation to colorectal robotic surgery, however, patient handling can be considered comparable to a conventional laparoscopic colorectal approach.

Cerebral and intraocular pressures

Trendelenburg position increases the intracranial pressure (ICP) due to the increased venous pressure [17,18]. Moreover, increased $PaCO_2$ from the pneumoperitoneum may induce cerebral arterial dilatation and further increase arterial blood flow [19]. Theoretically, these changes may induce cerebral edema, however studies have demonstrated that cerebral blood flow is not affected by these changes [20]. Nevertheless, it must be considered that patients with preoperatively increased ICP, such as intracerebral pathology, should probably avoid the positioning applied in robotic and laparoscopic colorectal surgery. Similarly, studies have demonstrated that intraocular- and orbital pressures may increase during Trendelenburg position [21]. Therefore, patients with known ocular pathology, such as nerve defects or advanced glaucoma, should avoid robotic/ laparoscopic technique or undergo medical treatment by an ophthalmologist before surgery.

Airway and pulmonary management

During the surgical procedure there is a risk of tube dislocation into the right mainstem bronchus due to patient sliding and anatomical changes during pneumoperitoneum [22]. Furthermore, pneumoperitoneum and Trendelenburg positioning reduce pulmonary compliance and residual capacity, increase the risk of atelectasis, and induce ventilation/perfusion mismatch [23]. These physiological changes, increasing lung peak pressures may impair oxygenation of the patient. Therefore, lung protective pressure-controlled ventilation strategies, recruitment maneuvers and positive end-expiratory pressures can be applied [24]. Furthermore, periods of horizontal patient positioning and pauses in surgery, including undocking may be needed in selected cases (e.g. due to severe metabolic and/or respiratory acid-base imbalance). Postoperatively, larynx edema may occur after extended head-down positioning, and the may induce postoperative stridor [25].

Cardiovascular concerns

The combined effect of the pneumoperitoneum and Trendelenburg position may in frail patients induce significant changes in cardiovascular function [26-28]. The clinical impact depends on patient characteristics, anesthesia and operative techniques, however, the main cardiovascular changes during pneumoperitoneum are increases in mean arterial pressure, systemic resistance and heart rate [27]. These physiological changes are accompanied by effects of the head-down position, which include increased venous return and cardiac output [26]. Collectively, these changes in cardiovascular function are normally well tolerated, and can be accepted without changing surgical approach.

Renal dysfunction and fluid management

Several experimental studies have demonstrated that renal blood flow and function may be reduced during pneumoperitoneum [29]. Furthermore, a randomized clinical study documented impaired renal function in patients undergoing laparoscopic surgery compared to open technique [30]. However, renal impairment during pneumoperitoneum is temporary, and therefore a possible clinical impact remains uncertain [29,30].

In colorectal surgery controversies still exist in relation to procedure-specific fluid management. Several studies have documented improved pulmonary- and cardiovascular function, reduced complications rates, reduced ileus and reduced length of stay by applying a restrictive fluid regimen in open colorectal procedures [31]. Therefore, until further evidence in either laparoscopic or robotic colorectal surgery exists, a restrictive fluid regimen should be applied. Future studies may document positive clinical effects of goal-directed fluid therapy and optimal types of IV fluid in elective colorectal surgery, but these issues need to be clarified further [32,33].

Anesthetic regimen

Anesthesia for robotic surgery should ideally induce optimal sleep, amnesia, analgesia and neuromuscular block to perform a safe surgical procedure. Furthermore, the regimen should provide quick postoperative recovery. No randomized studies have investigated patient-related outcomes in relation to the anesthetic techniques in robotic colorectal surgery.

The choice between total intravenous anesthesia (TIVA) and inhalation anesthetics must depend on local experience and preference. In other fields of surgery, some studies have demonstrated that TIVA might be superior with respect to improved postoperative cognitive function [34] and the occurrence of postoperative nausea and vomiting (PONV) [35,36], but no evidence-based recommendations can be made in colorectal surgery at this moment. However, volatile anesthetics are also becoming increasingly unfavoured due to environmental issues and possible personnel safety concerns [37,38].

Propofol provides a well-documented anesthetic effect, a high degree of patient satisfaction and a low risk of adverse effects [39]. The combination of propofol and opioids may induce hypotension and bradycardia, which can be corrected with optimal fluid management, reduction of anesthetic dosages or administration of vasopressors [40].

The type of intraoperative opioid may also depend on local preference, however short-acting types are generally recommended to improve rapid patient recovery [41]. The ultra short-acting opioid remifentanil can be administered as an intraoperative infusion, with loading of fentanyl for postoperative analgesia before ending of the surgical procedure. Intraoperative dosage titration (opioids/

anesthetics) may be performed depending on cardiovascular parameters and possible bispectral monitoring (BIS).

Deep neuromuscular block is required during robotic surgery to prevent sudden movements of the patient during the surgical procedure. With the robot in a "docked" position, immediate removal of surgical instruments is impossible. Therefore, surgical instruments may pose a danger in case of sudden patient movements, and can cause perforation of vital organs such as the liver, spleen, bowel or even large vessels. Therefore, mandatory neuromuscular blocking agents should be administered as bolus or infusion, and continuous neuromuscular monitoring such as train-of-four/post tetanic count (TOF/PTC) during the surgical procedure should be applied [42]. Finally, sugammadex can be used to facilitate fast reversal of deep rocuronium-induced neuromuscular block, and reduce the risk of postoperative residual curarization [43].

Multimodal analgesic treatment

Optimal analgesic treatment should provide sufficient analgesia to facilitate mobilization of the patient, and reduce the risk of postoperative complications [41,44]. These goals of treatment require an evidence-based multimodal procedure-specific perioperative approach [45]. No studies investigating robotic colorectal procedures have provided any solid evidence concerning procedure-specific analgesic treatment or incorporated the concept of a multimodal analgesic approach. However, the surgical trauma can be compared to laparoscopy and recommendations may be transferred from this field, and from other comparable colorectal procedures [45,46] (Table 1).

Preparation phase
- Secure venous cannulas, tubes and patient monitoring equipment before docking
- Perform positioning check before docking of robot
Surgical and medical emergencies
- Emergency protocols and sustained training of personnel
Recommended procedure-specific anesthetic treatment
- Preoperative dexamethasone
- Induction: propofol + remifentanil or fentanyl
- Maintenance: propofol + remifentanil (fentanyl loading before emergence)
- Neuromuscular block: rocuronium (as infusion)
Recommended procedure-specific postoperative analgesic treatment
- Acetaminophen, fixed intervals
- COX-1 selective NSAIDs, fixed intervals
- Oral opioids, as needed
- Local anesthetics (as infiltration or TAP) can be used

Table 1: Recommendations for a standard care program in robotic colorectal surgery, NSAIDs: non-steroidal anti-inflammatory drugs; TAP, transversus abdominis plane block.

Preoperative administration of dexamethasone has been shown to improve both analgesia and PONV in comparable procedures, and should be administered as part of a fast-track robotic colorectal perioperative regimen [47].

The administration of acetaminophen in fixed intervals has documented analgesic effect in randomized trials investigating both laparoscopic abdominal surgery (including colorectal procedures) and major surgery in general [48-50].

NSAIDs reduce pain scores and analgesic requirements in randomized trials in laparoscopic colorectal surgery and in comparable abdominal procedures [50,51]. However, recent studies have linked the administration of COX-2 selective NSAIDs to anastomotic leakage [52]. Furthermore, NSAIDs in general have been shown to increase the risk of cerebro- and cardiovascular events, even with shorts-term use [53,54]. Until further documentation becomes available, non-selective or COX-1 selective NSAIDs (e.g. ibuprofen or similar) should be preferred in the postoperative period following robotic colorectal surgery.

Opioids are required for optimal analgesia in most colorectal procedures, however oral administration has been shown to be sufficient in laparoscopic colorectal surgery [55]. Furthermore, oral opioid administration compared to patient-controlled analgesia is safe, cheaper, does not require patient-education, and does not reduce mobility of the patient.

Epidural block is well documented in open colorectal surgery, demonstrating reduced surgical stress, improved lung function, gut motility and analgesic efficacy [56]. In laparoscopic surgery these advantages have not been documented to the same extent, probably due to the different nature of the procedure, and the reduced surgical insult [57-61]. On the contrary, the risk of adverse effects, such as hypotension, urine retention and paresis are commonly experienced with epidural analgesia. Therefore, epidural block cannot at this moment be recommended as part of an optimized analgesic regimen in elective robotic colorectal surgery.

Only limited randomized evidence exist in laparoscopic colorectal surgery with respect to local anesthetics, administered intravenously [62,63], as infiltration analgesia (no studies available), subcutaneous infusion [64], intraperitoneal administration [65] or tranversus abdominis plane (TAP)-block [66], whereas no studies have investigated any of these analgesic modalities in robotic surgery. The administration routes for local anesthetics and possible analgesic effects after robotic colorectal surgery should therefore be investigated further in future research.

Finally, alternative analgesics such as gabapentin and ketamine remain to be investigated as part of a multimodal analgesic regimen in robotic colorectal surgery.

Conclusions

Robotic surgery is being increasingly applied in colorectal surgery. A more detailed knowledge of the specific anesthesiological challenges during robotic surgery is needed to ensure optimal treatment and patient safety. Focus of the clinician should be drawn towards the preparation phase and knowledge of the physiological changes and patient handling in relation to Trendelenburg positioning and pneumoperitoneum. Moreover, deep neuromuscular block is required during robotic surgery. Lessons learned from laparoscopic colorectal surgery can be applied with respect to anesthetic- and postoperative analgesic treatment until further evidence is provided.

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