Special Article

Anaesthetic management of robot-assisted laparoscopic surgery

Address for correspondence:
Dr. Chhaya M Suryawanshi, Department of Anaesthesiology, Dr. D. Y. Patil Medical College, Hospital and Research Centre, Dr. D. Y. Patil Vidyapeeth, Pimpri, Pune, Maharashtra, India.
E-mail: chhayasuryawanshi@gmail.com

Submitted: 29-Nov-2022
Revised: 28-Dec-2022
Accepted: 29-Dec-2022
Published: 21-Jan-2023

Access this article online
Website: www.ijaweb.org
DOI: 10.4103/ija.ija_966_22
Quick response code

Chhaya M Suryawanshi, Bhavini Shah, Sangeeta Khanna[1], Poonam Ghodki[2], Kanta Bhati[3], Ashok K V[4]

Department of Anaesthesiology, Dr. D. Y. Patil Medical College, Hospital and Research Centre, Dr. D. Y. Patil Vidyapeeth, Pimpri, Pune, Maharashtra, [1]Department of Anaesthesia, Medanta - The Medicity, Gurugram, Haryana, [2]Department of Anaesthesia, Deenanath Mangeshkar Hospital and Research Centre, Pune, Maharashtra, [3]Sardar Patel Government Medical College, Bikaner, Rajasthan, [4]Department of Oncology and Transplant Services, HCG Hospital, Bengaluru, Karnataka, India

ABSTRACT

Recent trend shows that minimally invasive surgery is in great demand. Robot-assisted procedures have become more popular, as they overcome several drawbacks of traditional laparoscopic techniques. Robotic surgery, however, might necessitate changes in how patients are positioned and how staff and equipment are organised generally, which might go against the traditional approach to anaesthesia care. The novel effects of this technology have the potential to produce paradigm-shifting therapeutic improvements. To provide better anaesthetic treatment and advance patient safety, anaesthesiologists should be aware of these developments by understanding the fundamental components of robotic surgical systems.

Key words: Anaesthesia, laparoscopy, robotic-assisted surgery

INTRODUCTION

Over the past few decades, minimally invasive surgical techniques, mostly laparoscopic ones, have transformed surgery. Smaller surgical incisions, less discomfort, a shorter hospital stay, and speedier recovery are some of the possible benefits for patients; however, the view is two-dimensional and utilises long devices with restricted manoeuvrability.

Robotic surgery pushes the limits of technological innovation in health care in the direction of better clinical results. The potential for better visualisation (higher magnifications with stereoscopic views), elimination of hand tremors allowing greater precision, and improved manoeuvrability due to the 'robotic wrist', which in some systems allows up to 7 degrees of freedom, are all advantages of the robots for surgeons (angles at which surgeons can use their instruments to operate on target organs).

The most popular surgical robot today is the Da Vinci Robotic System (Intuitive Surgical Inc., Mountain View, CA), which was released in the year 2000 [Figure 1]. This apparatus includes master console, a robotic surgical manipulator, and a visualisation tower.[1]

The specific pathophysiological changes that take place during surgery must be understood by surgeons and anaesthesiologists in order to treat intraoperative and post-operative problems. Furthermore, the

This is an open access journal, and articles are distributed under the terms of the Creative Commons Attribution-NonCommercial-ShareAlike 4.0 License, which allows others to remix, tweak, and build upon the work non-commercially, as long as appropriate credit is given and the new creations are licensed under the identical terms.

For reprints contact: WKHLRPMedknow_reprints@wolterskluwer.com

How to cite this article: Suryawanshi CM, Shah B, Khanna S, Ghodki P, Bhati K, Ashok KV. Anaesthetic management of robot-assisted laparoscopic surgery. Indian J Anaesth 2023;67:117-22.

Figure 1: Fourth generation Da Vinci robotic system

multidisciplinary team members participating in robotic surgery need to be more technically organised, better prepared, and able to communicate clearly and extensively.

GENERAL ISSUES

In India, the surgical robotic market is expanding at a compound annual growth rate (CAGR) of 19.80% during the 2019-2024 period (from 6 robots in 2009 to more than 100 in 2019). A functioning robotic surgical program is a matter of pride and prestige for the institute. The main downside is its prohibitive cost ranging between 1.5 and 2.5 million US dollars. The cost of maintenance may come to 10% of the acquisition cost, and the cost of supplies and instruments is nearly one-third of the average total cost.[2]

The robotic surgeon often acts as the captain of the ship with his role being to anchor a perioperative team of anaesthesiologists, surgical assistants, nurses, and technicians and to collectively set up protocols to efficiently run the program. The institute should also set performance benchmarks for quality and patient safety. In robotic prostatectomies, one can have 30 minutes of setup time, 200 minutes of intraoperative time, and 30 minutes of turnaround time as the initial benchmarks.[3,4]

Due to the bulky nature of the robot, Rocco *et al*.[5] proposed a minimum of 60 m^2 of square-shaped operating room (OR) with a rotatable OR table in the centre as per surgical requirement. The console should be preferably placed at the less frequented corners of the OR. The patient cart and vision cart are mobile units. The connecting cables should be detangled and placed in ergonomically correct places. The OR will be typical [Figure 2].

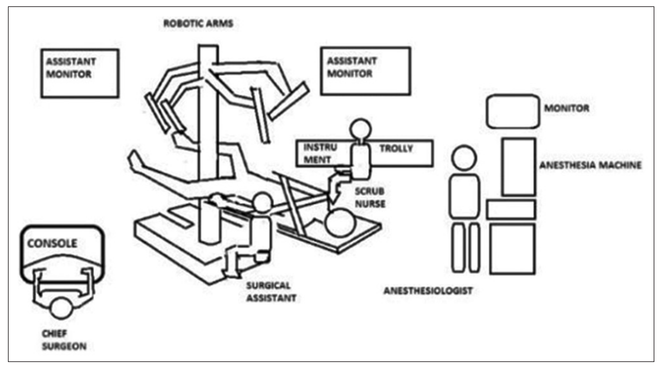

Figure 2: A typical operating room set-up (Adapted from the author's previous publication[2])

Ideally, two anaesthesiologists along with surgeons, circulating and scrub nurses, and technicians should be always available in the OR. Due to the dark environment and lack of situational awareness, close communication among team members is crucial to avoid any mishap. The technician and the nurses should be experts in the system start-up and preparing the robot for surgery. Patient positioning should be well-planned to avoid physical injuries and neurological complications. Hence, training and retraining the team is important as it improves confidence, quality, and safety of costly instruments which are major determinants for the program's economic viability.

Indications and contraindications for robot-assisted laparoscopic surgery

The indications include a variety of gastrointestinal procedures such as ventral hernia repair,[6] gastrectomy, pancreaticoduodenectomy and donor hepatectomy, head and neck procedures including transoral surgeries, facelifts, thyroidectomy, gynaecological surgery such as salpingo-oophorectomy, hysterectomy, staging and debulking of tumours, urological procedures like radical prostatectomy/cystectomy/ nephrectomy and orthopaedic procedures such as arthroplasty (knee, hip). Paediatric procedures like pyeloplasty/nephrectomy, uretero-ureterostomy and cardiothoracic surgical procedures such as the correction of congenital heart disease (CHD), cardiac tumour resection, oesophagogastrostomies, oesophago-gastrectomies, lobectomies and diaphragmatic tumour are other examples where robot-assisted laparoscopic technique can be used.

There is no absolute contraindication to robotic surgery[7] though factors like disease severity, and surgical and anaesthesiologist inexperience can result in a high risk of harm. In such cases, modifications like insufflation speed, and shorter duration of Trendelenburg position with an experienced surgeon, may enable the surgery to proceed.

Relative contraindications include ventral hernia repair, cirrhosis/ascites, laparotomy for large tumours, chronic obstructive pulmonary disease, pulmonary artery hypertension, CHD, etc.[7]

Limitations

The technique is associated with several limitations such as high cost and maintenance,[8] prolonged operating room time, limited tactile feedback, lack of proximity to the patient and limitation of device availability on a robotic platform. Robotic instruments are limited-use consumables and must be purchased repeatedly.

Their use requires specialised training and skills and sufficient operating room space for bulky equipment. Precarious positioning and limited access to the patient after docking are possible. Professional liability, litigation, ethical issues, equipment safety, reliability, provision of adequate information and maintenance of confidentiality are of paramount importance.

Goals of robot-assisted laparoscopic surgery

To ensure patient safety, the operational field exposure has to be maximised, arm collision minimised, and the surgical team efficiency improved.

All staff involved should have a complete understanding of the robotic system, including the positioning of the robot (docking), the surgical console, and the safety measures. All staff should produce a final evaluation of the robotic system, both theoretical and practical, by visiting reference centres, assisting procedures, and performing simulation training.

Docking

It is attaching the patient cart instrument arms to the patient after positioning of patient and insertion of ports. After docking, even small adjustments to the position of the operating table and/or patient become particularly delicate, if not impossible; similarly, it will be very difficult to perform any anaesthetic manoeuvre or placement of new vascular accesses. It is recommended that the anaesthesia workstation is positioned in a way that allows the patient's monitors to be visible and rapid access to the anaesthesia equipment if needed. All OR personnel should pay attention to the correct positioning of the patient on the operating table.

In case of any surgical or anaesthetic urgency or emergency, one should assess whether the situation calls for a temporary or permanent suspension of the robotic approach, by establishing an effective collaboration and communication among the OR personnel. An internal protocol that defines a safe emergency undocking procedure (after checking that the robotic devices are free from the outlets) should be created, and simulation training of the same should be done.

PREOPERATIVE PREPARATION

The preoperative preparation for a patient scheduled for robotic surgery encompasses preoperative assessment and specific ergonomics preparation.

A routine preoperative anaesthetic assessment with identification of high-risk patients should be carried out. Most of the patients coming for robotic urological or arthroplasty procedures would be elderly or obese and the physiological impact of these should be known by the anaesthesiologist.[9] Advancement in both robotics and anaesthesia delivery system, makes it possible for more high-risk patients being selected for robotic or minimally invasive surgery because of the overt advantages. The extreme positions demanded for robotics have detrimental impact on cardiovascular and/respiratory physiology.[10] A history of glaucoma should be ruled out as the patient position is associated with increased intraocular pressure and cerebral blood volume.[11] Such patients should be identified through clinical examination and investigations. Meanwhile, psychological preparation of these patients, explaining the procedure, positioning, and the realm of complications may aid in uneventful recovery.

Approach to intravenous lines may be tricky during surgery, and preferably two wide bore intravenous cannulae should be secured prior to docking. Routine cases may be managed without invasive monitoring. Antithrombotic, antibiotic and, aspiration prophylaxis protocol should be followed. Heparin administration, pneumatic compression devices, and stockings play pivotal roles in the prevention of deep venous thrombosis. Preoperative fasting hours should be according to enhanced recovery after surgery (ERAS) protocol.[12]

INTRAOPERATIVE MANAGEMENT

Apart from the standard informed consent, an additional written and informed consent should be taken from the patient after explaining complications that may arise from prolonged duration of surgery as well as pneumoperitoneum and surgical position (deep Trendelenburg/reverse Trendelenburg) related issues [Table 1].

Monitoring

All American Society of Anesthesiologists (ASA) standard monitoring including electrocardiogram, pulse oximetry, blood pressure, capnometry, and temperature monitoring should be available. Hourly input and output charting, respiratory gas monitoring, train of four (TOF) and bispectral index (depth of anaesthesia) monitoring are essential. Invasive blood pressure and central venous pressure monitoring may be indicated in some cases (with appropriate consents).[13]

Table 1: Physiological effects of Trendelenburg position[17]

System	Changes
Cardiovascular system	Increase in systemic vascular resistance, mean arterial pressure, myocardial oxygen consumption
	Decrease in renal, portal and splanchnic flow
Respiratory system	Increase in ventilation-perfusion mismatch, peak airway pressure (P_{PEAK})
	Decrease in functional residual capacity, vital capacity, compliance
	Pulmonary congestion and oedema
	Hypercarbia, respiratory acidosis
Central nervous system	Increase in intracranial pressure, cerebral blood flow, intraocular pressure
Endocrine	Catecholamine release
	Activation of renin-angiotensin system
Others	Gastro-oesophageal regurgitation
	Venous air embolism
	Neuropraxia
	Tracheal tube displacement
	Facial and airway oedema
	Visceral/Vascular injury

Conduct of anaesthesia

The conduct of anaesthesia should be planned and modified as per the patient's medical condition. Standard general anaesthesia induction is indicated, and it includes securing the airway with appropriately sized endotracheal tube which should be properly taped and secured as there are high chances of endobronchial migration of tube resulting in collapse of non-ventilated lung and hypoxaemia (patient positioning and pneumoperitoneum related). Three-point endotracheal tube cuff palpation technique, intubation guide mark technique and Varshney's formula can be used to help in achieving the optimal endotracheal tube tip-carina distance during endotracheal tube placement. In a recently published study, the authors found that the three-point endotracheal tube cuff palpation technique is simple, reliable and effective in preventing endobronchial tube migration during robotic pelvic surgery.[14] Furthermore, tube placement should be checked frequently. Tidal volume should be maintained between 6 and 8 ml/kg with plateau pressure (P_{PLAT}) not exceeding 30 cm of H_2O. Lung protective ventilation should be applied.[15,16] As with traditional minimally invasive techniques, nitrous oxide is avoided for robotic procedures since it may cause bowel distension. Endotracheal tube cuff pressure monitoring would be useful. Positive end-expiratory pressure (4-7 cm of H_2O) decreases the likelihood of atelectasis, improves respiratory mechanics, and restores functional residual capacity. Prolonged surgical duration makes it sensible to use volatile agents with good recovery profiles for maintenance like desflurane or sevoflurane. The procedure also requires good depth of muscle relaxation with TOF monitoring to avoid any movements by the patient, while the surgical instruments are in place to avoid visceral injury. The patient remains paralysed until the robot is undocked at the end of the procedure. The positions used in robotic surgeries are far more extreme when compared to laparoscopic and conventional surgeries. Hence, belts and restraints must be used to prevent patients from falling off the OR table. The degree of limb extension, stirrup position, padding of bony prominences, and eyes should be considered. Only when the patient has been placed in the best possible posture should the robot be docked. Constant vigilance is needed to avoid pressure/crush injuries from direct contact of the robotic arms with the patient. Balanced salt solutions are preferred for fluid maintenance with the aim of maintaining euvolaemia or near-zero fluid balance.[17] Hypothermia must be avoided using a body warmer or warming mattress.

Fluids, pneumoperitoneum, and the patient's position increase the likelihood of airway oedema and unsuccessful extubation. Cognitive recovery may be slowed down by cerebral oedema and increased intracranial tension during lengthy head-down surgery. A predictor of concurrent airway oedema is the presence of periorbital oedema. Optic nerve sheath diameter by ultrasonography may help in trying to gauge the laryngeal oedema. Prior to extubation, an airway leak test is performed to assess the likelihood of post-extubation stridor.[18] Patients who do not satisfy the requirements for extubation should be ventilated electively in the post-anaesthesia care unit. Post-extubation airway issues that lead to post-operative respiratory discomfort and may need re-intubation include stridor, laryngeal oedema, blockage and tracheal deviation.

POST-OPERATIVE MANAGEMENT

Patients are usually extubated on table post-procedure and rarely require elective ventilation. However, most patients require one or two days of stay in an intensive care unit (ICU). Post-operative complications are usually less. Blood transfusion is rarely required. Occasionally paralytic ileus may manifest.

Post-operative evaluation should include identification of the most suitable care path (ward, recovery room, intermediate/step-down care, or ICU) consideration of any existent comorbidities, procedure-associated risks and possible intraoperative complications. A careful monitoring for specific complications associated with pneumoperitoneum or patient positioning, such as subcutaneous emphysema, (delayed) hypercarbia, capnothorax should be done. Adopting a score for traditional surgery helps to objectively assess clinical stability (e.g. Modified Aldrete, White and Song).

The key points in the post-operative management are early ambulation and adequate analgesia.[19]

Despite lesser degree of pain, multimodal analgesia is implemented to prevent pulmonary complications and faster recovery. Systemic analgesia can be provided with non-steroidal anti-inflammatory drugs such as paracetamol and diclofenac sodium, and opioids like fentanyl and tramadol. Regional analgesic techniques include epidural anaesthesia for thoracic and gastrointestinal surgeries, intercostal blockade in thoracic and upper abdominal surgeries and transversus abdominis plane block for abdominal procedures. Hydration is maintained with intravenous fluids (balanced salt solutions) and early oral intake. A multimodal approach for the prevention and treatment of post-operative nausea and vomiting according to specific guidelines is recommended. Deep vein thrombosis prophylaxis is administered. Chest physiotherapy to reduce pulmonary complications which can otherwise increase the ICU and hospital stay is important post-operatively. [20,21]

SUMMARY

Robotic surgery is becoming more prevalent and is being increasingly used in various specialities. Hence, anaesthesiologists need to stay abreast of current knowledge and be prepared to give better quality of anaesthesia care to these patients. Further studies should focus on resident training, cost-effectiveness, and long-term outcomes in anaesthesia for robotic surgery.

Financial support and sponsorship
Nil.

Conflicts of interest
There are no conflicts of interest.

REFERENCES

1. Irvine M, Patil V. Anaesthesia for robot-assisted laparoscopic surgery. Cont Educ Anaesth Crit Care Pain 2009;9:125-9.
2. Khanna S, Das J, Kumar S, Mehta Y, Ahlawat R. Being intuitive: Starting a comprehensive multispecialty robotic surgery programme. OA Robot Surg 2014;15:2-8.
3. Patel V, Palmer K, Coughlin G, Samavedi S. Robot-assisted laparoscopic radical prostatectomy: Perioperative outcomes of 1500 cases. J Endourol 2008;22:2299-305.
4. Tewari A, Jhaveri J, Surasi K, Patel N, Tan G. Benefit of robotic assistance in comparing outcomes of minimally invasive versus open radical prostatectomy. J Clin Oncol 2008;26:4999-5000.
5. Rocco B, Lorusso A, Coelho R, Palmer K, Patel V. Building a robotic program. Scand J Surg 2009;98:72-5.
6. Kudsi OY, Paluvoi N, Bhurtel P, McCabe Z, El-Jabri R. Robotic repair of ventral hernias: Preliminary findings of a case series of 106 consecutive cases. Am J Robot Surg 2015; 2:22-6.
7. Tameze Y, Low Y. Outpatient robotic surgery: Considerations for the anesthesiologist. Adv Anesth 2022;40:15-32.
8. Ashrafian H, Clancy O, Grover V, Dari A. The evolution of robotic surgery: Surgical and anaesthetic aspects. Br J Anaesth 2017;119:i172-84.
9. Schrijvers D, Mottrie A, Traen K, De Wolf AM, Vandermeersch E, Kalmar AF, *et al*. Pulmonary gas exchange is well preserved during robot assisted surgery in steep Trendelenburg position. Acta Anaesthesiol Belg 2009;60:229-33.
10. Gainsburg DM. Anesthetic concerns for robotic-assisted laparoscopic radical prostatectomy. Minerva Anestesiol 2012;78:596-604.
11. Awad H, Santilli S, Ohr M, Roth A, Yan W, Fernandez S. The effects of steep trendelenburg positioning on intraocular pressure during robotic radical prostatectomy. Anesth Analg 2009;109:473-8.

12. Scott M, Fawcett W. Oral carbohydrate preload drink for major surgery- the first steps from famine to feast. Anaesthesia 2014;69:1308-13.
13. Kapur A, Kapur V. Robotic surgery: Anaesthesiologist's contemplation. Malays J Med Sci 2020;27:143-9.
14. Mittal AK, Dubey J, Shukla S, Bhasin N, Dubey M, Jaipuria J. Efficacy of the three-point cuff palpation technique in preventing endobronchial tube migration during positioning in robotic pelvic surgeries. Indian J Anaesth 2022;66:818-25.
15. Wirth S, Baur M, Spaeth J, Guttmann J, Schumann S. Intraoperative positive end-expiratory pressure evaluation using the intratidal compliance-volume profile. Br J Anaesth 2015;114:483-90.
16. Gupta K, Mehta Y, Sarin Jolly A, Khanna S. Anaesthesia for robotic gynaecological surgery. Anaesth Intensive Care 2012;40:614-21.
17. Corcione A, Angelini P, Bencini L, Bertellini E, Borghi F, Buccelli C. Società Italiana di Anestesia Analgesia Rianimazione e Terapia Intensiva (SIAARTI) and Società Italiana di Chirurgia (SIC). Joint consensus on abdominal robotic surgery and anesthesia from a task force of the SIAARTI and SIC. Minerva Anestesiol 2018;84:1189-208.
18. Phong SV, Koh LK. Anaesthesia for robotic-assisted radical prostatectomy: Considerations for laparoscopy in the trendelenburg position. Anaesth Intensive Care 2007;35:281-5.
19. Batley S, Prasad V, Vasdev N, and Mohan G. Postoperative pain management in patients undergoing Robotic urological surgery. Curr Urol 2016;9:5-11.
20. Pramanik M, Sarkar A, Gupta A, Chattopadhyay M. Post operative pulmonary complications in robotic assisted uro-oncological surgeries. Indian J Anaesth 2020;64:238-41.
21. Burks C, Nelson L, Kumar D, Fogg L, Saha C, Guirguis A. Evaluation of pulmonary complications in robotic-assisted gynecologic surgery. J Minim Invasive Gynecol 2017;24:280-5.