Chapter

Perspective Chapter: Anaesthetic Management for Robotic Surgery

Amr Ashour, Ahmed Aboelezz, Mohamed Hussein, Mustafa Rehan and Belal Khalil

Abstract

Robotic surgery has been widely adopted by many centres as it provides optimum surgical conditions for management of various cases with improved outcomes over the past decade. Being a relatively new technique, anaesthesia for robotic surgery has become a part of daily work that anaesthetists should know about. This chapter aims to provide a comprehensive review about latest advances in robotic surgeries, indications, and contraindication, the perioperative management plan, and recent techniques to provide pain relief for intra- and postoperative care focusing on the latest PROSPECT guidelines. It will highlight the possible complications that should always be kept in mind during and after surgery period.

Keywords: robotic surgery, preoperative assessments, intraoperative managements, postoperative complications, pain management, PROSPECT guidelines

1. Introduction

1.1 History of robotic-assisted devices in medicine

The field of medicine is undergoing a revolution with the emergence of robots. Various factors such as miniaturisation, artificial intelligence, and computer power are helping in the design and development of these robotic systems [1].

About 34 years ago, medical robots started to emerge when a CT navigation system and an industrial robot were used to carry out a biopsy procedure on the brain. Eventually, medical robots were able to perform various surgical procedures, such as total hip arthroplasty and urological procedures. Unfortunately, these fully autonomous robots were not popular with surgeons [1].

The technology drew the attention of the US Department of Defence, which invested in it to allow performing surgeries over troop casualties without jeopardising the medical team using satellites. The project faced various technical issues, mainly due to the delay in response time. However, the project facilitated the development of the Da Vinci System which was introduced to the medical system in 1999 [1].

1.2 Surgeries and robotic-assisted devices

In the past few decades, surgical techniques have witnessed major changes from open techniques towards minimally invasive ones, saving patients a large, traumatic, and painful incision. Not only positively affecting the patients but also saving costs from prolonged hospital stay and recovery time [1].

The evolution of minimally invasive techniques using small cameras did not pass without a cost. The two-dimensional (2D) flattened visual operative field limited the surgical techniques and flexibility until 1985, when the robot PUMA 560 performed a CT-guided brain biopsy that opened a new world of minimally invasive techniques, allowing better 3D visual field surgeries [1].

1.3 The Da Vinci System

The Da Vinci System comprises three parts: a console, a robotic manipulator, and a visualising tower. The console consists of an eyepiece giving 3D image, two actuators controlling the robot's arms and foot pedals allowing change between control of camera and robotic arms and changing the diathermy power. The visualising tower carries images from the camera to display to the theatre team. The robotic manipulator consists of three arms; one holds the camera, and the other two carry different surgical instruments. The camera is slightly different from the endoscopic camera as it contains two cameras that fuse the images together to give the surgeon a 3D image with real depth. The system has advanced technology to filter hand tremors and allows precise movement. Moreover, instrument arms have a higher degree of free mobility than conventional laparoscopic arms to approximate the human hand's range of movement (**Figure 1**) [2].

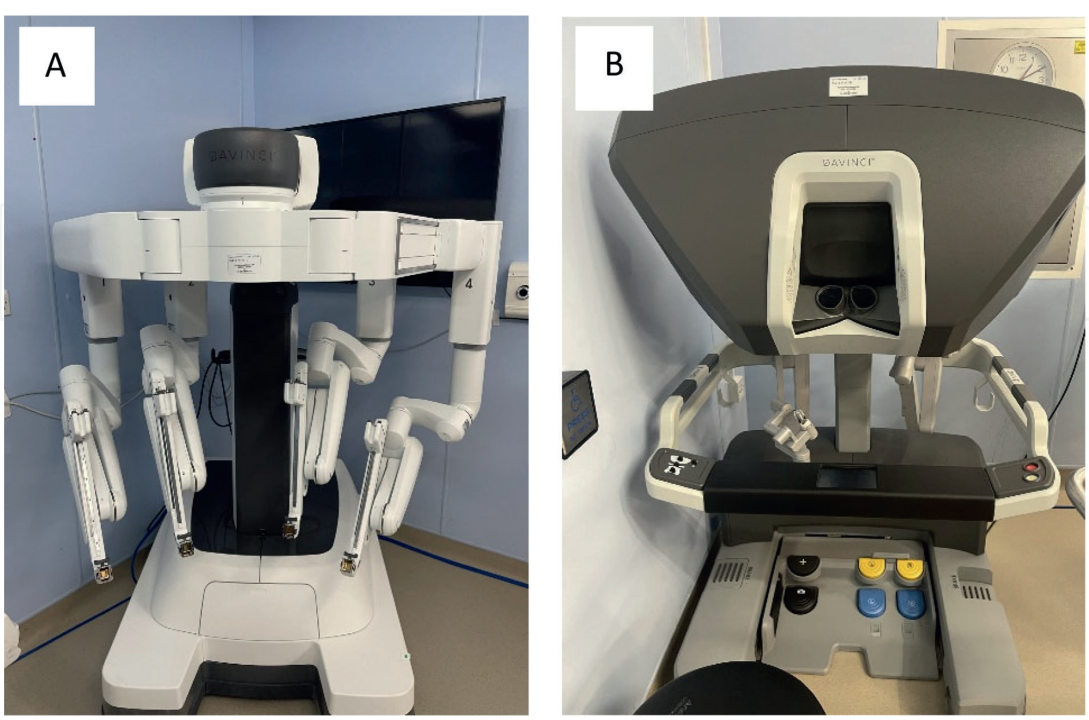

Figure 1.
The Da Vinci robot (a) console (b) robotic manipulator and visualising tower—Southend University Hospitals NHS Trust Theatre.

In spite of the advanced technology of the Da Vinci System, it has its drawbacks. The system requires a surgeon to insert the robotic arms through a laparoscopic-sized hole. So, remote surgery is still possible but needs a surgeon in the field. The Da Vinci System is a relatively new technology costing around 1.5 million Pound with yearly service of around 125 thousand and 2000 Pound per case, which is considered a high cost for most of the UK trusts [3]. However, the high cost could be equilibrated with the lower cost of hospital stay after the surgery and lower incidence of complications that have been reported especially with the use of robotic surgery in prostatectomy. Moreover, the learning curve of robotic surgeries is relatively long when compared with laparoscopic surgeries, for example, which is time-consuming and may result in prolonged surgeries, also reflected in the cost of robotic surgery. Robotic surgery has an ergonomic issue and requires a spacious operating theatre with the theatre team, not only surgeons and anaesthetists, who are familiar with the procedure and machine. From an anaesthetic point of view, any patient movement could lead to a disastrous result once the robotic arms are locked inside the patient's body, requiring complete muscle relaxation [4].

The Da Vinci System is reliable, with a failure rate leading to open surgery approaching 0.5%. The lower risks of postoperative complications have led to a global shift towards robotic surgeries [4, 5]. A study published in the *Journal of American Medical Association* regarding robotic surgeries for bladder cancer and reconstruction has found a reduced chance for re-admission by 52%, quicker recovery by 20%, and reduced prevalence of blood clots (deep venous thrombosis (DVT) and pulmonary emboli) by 77%. The system has been introduced to various surgical specialities including general, cardiothoracic, gynaecological, paediatric, neurological, and recently urological surgeries [6].

1.4 Pneumoperitoneum

Pneumoperitoneum is required to facilitate robotic surgery. As the name suggests, the gas used in pneumoperitoneum is carbon dioxide (CO_2). CO_2 has multiple advantages to be used in pneumoperitoneum rather than air or any other gas. CO_2 is an inert gas that does not readily undergo chemical reactions with other substances and does not support combustion that will allow the safe use of diathermy. It also has a significant solubility, decreasing the risk of gas embolism if injected into a blood vessel mistakenly [7, 8].

There are multiple considerations that should be kept in mind due to pneumoperitoneum. The abdomen and the pelvis are relatively closed spaces, and when the gas is injected, it will lead to increased intra-abdominal pressure (IAP). At the start, the movement of the diaphragm and the anterior abdominal wall will accommodate for the increased IAP. With increased pressure, the compensatory mechanism will fail, resulting in a rapid increase in the IAP. The sequela of the increased IAP is compression of the inferior vena cava, major arteries, and visceral blood vessels. That will lead to decreased venous return to the heart, dropping the cardiac output (COP) and pooling of blood in the abdomen, facilitating the development of deep venous thrombosis. The raised IAP will also be reflected in increased pressure on other closed spaces such as the brain leading to increased intracranial tension (ICT) [9].

The change in IAP is biphasic: A mild increase in the IAP (<10 mmHg) will lead to an increase in venous return, causing elevation in COP and blood pressure. Further, an increase in IAP (10–20 mmHg) will reduce COP and increase systemic vascular resistance, which will be reflected variably in blood pressure. When IAP is raised above 20 mmHg, the drop in COP becomes significant, leading to a drop in blood pressure [10].

Pneumoperitoneum also affects respiratory function by splitting the diaphragm, leading to basal atelectasis affecting the ventilation/perfusion matching. The CO_2 is absorbed into the circulation by the large peritoneal surface, even after deflation, leading to a rise in arterial CO_2, reducing the partial pressure of O_2 in alveoli [11].

In addition to previous changes, pneumoperitoneum increases the pressure on the small blood vessels supplying the viscera. A relatively small rise in IAP from 10 to 15 mmHg significantly affects the blood supply to stomach, liver, and small and large intestines, increasing the risk of ischaemic injury. The retroperitoneal structures are relatively preserved; however, there is a reduction in renal blood flow, resulting in an alteration of renal function [12].

The effects of pneumoperitoneum are exaggerated by the change in position. Trendelenburg position will add to the negative effect exerted on lungs; however, it will improve the venous return. On the other hand, the reverse Trendelenburg position will reserve the venous return but will deteriorate the respiratory function [13, 14].

2. Preoperative considerations of robotic surgery

2.1 Common indications of robotic surgery in the practice

Robotic techniques have become standard practice in urology, particularly for procedures like prostatectomy, uncomplicated adrenalectomy, and nephrectomy, including live donor nephrectomy. In gynaecologic surgery, robotics play a crucial role in procedures such as tubal surgery (sterilisation, treatment of ectopic pregnancy, etc.), cystectomies, hysterectomies, various ablations (endometriosis), and more. Robotic surgery is also applied during pregnancy and in paediatric cases [15].

The realm of robotic general surgery encompasses a wide range of procedures, including cholecystectomy, hernia repair, anti-reflux procedures, splenectomy, appendectomy, bowel surgery (including bariatric procedures), and various upper and lower abdominal interventions. Recent advancements extend the application of robotics to thoracoscopic, cardiovascular, and neurosurgical intracranial surgeries, utilising modified laparoscopic instruments without the need for gas insufflation [16].

Additionally, emerging trends include lumbar discectomies and other forms of spinal surgery performed laparoscopically through an anterior approach. Remarkably, even autopsies have been explored using laparoscopic techniques. The ongoing expansion of robotic applications in diverse medical fields continues to broaden the scope of minimally invasive procedures [16].

2.2 Contraindication of robotic surgeries

Most of the contra-indications of robotic surgeries could be reverted by surgical team experience. However, contra-indications of robotic surgery should be excluded during preoperative assessment as robotic surgeries are better avoided in these conditions [17].

Contra-indications of robotic surgery could be divided based on systems:

- CNS: increased intracranial pressure, space-occupying lesion, retinal detachment, acute glaucoma, shunts (at risk of gas emboli and shunt obstruction).

- Cardiorespiratory: severe cardiovascular or pulmonary disease, hypovolemic shock, bullae, severe right, or biventricular failure, right to left cardiac shunt.

- Renal: impending renal shutdown.

- Abdominal: peritonitis, large intra-abdominal mass, abdominal wall tumour, history of extensive surgery or adhesions, diaphragmatic hernia, morbid obesity.

- Haematological: coagulopathy, sickle cell disease (risk of precipitation of sickle cell crisis with acidosis).

To summarise, contra-indications are related to the ability of the patient to tolerate extremes of position, pneumoperitoneum, and hypercarbia. It is worth mentioning that pregnancy is no longer considered a contraindication for robotic surgery, provided that the anaesthetist keeps in mind the effect of robotic surgery on maternal and fetal changes. Arterial gas monitoring with pre and postoperative fetal and uterine monitoring is essential [17].

2.3 Preoperative assessment

Vigilant assessment of the cardiopulmonary system is mandatory in preoperative assessment due to the reasons mentioned before. The effect of age on pulmonary function should always be kept in mind as with increased age, the functional residual capacity (FRC) decreases. Smoking and chronic obstructive pulmonary disease (COPD) cause a higher secretion with decreased ciliary clearance function, leading to further issues in ventilation added to the effect of pneumoperitoneum together, which may deteriorate the respiratory function. Respiratory infection might have a detrimental effect on intraoperative respiratory function and should be excluded until management with appropriate antibiotics. High BMI and deviation of the spine (Kyphoscoliosis) will add to the issues related to respiratory function. Assessment of exercise tolerance and the presence of shortness of breath will help in the formulation of plan of management. Thorough airway assessment should be considered especially if the patient is undergoing transoral robotic surgery (TORS). Difficult airway and obstructive sleep apnoea (OSA) are always considered in these types of surgeries [17].

Basic preoperative tests should be ordered in preoperative assessment including complete blood count, clotting functions, chemistry, electrolytes, renal function, ECG blood typing, and screening. Other laboratory tests may be required depending on the history taken. Baseline pulmonary function tests, chest X-ray, arterial blood gas, and saturation on room air might be helpful in patients with pulmonary diseases. Echocardiography, cardiac stress test, and cardiology clearance might be required for patients with cardiological symptoms [7].

Patients should be informed of possible complications of surgery as usual. He should be aware of the possibility of emergency laparotomy with possible blood transfusion and intensive care unit admission. Preoperative bowel preparation and antibiotics could be required before surgery in some surgical intervention.

3. Intraoperative considerations of robotic surgery

3.1 Anaesthetic technique

General anaesthesia with cuffed endotracheal tube insertion with controlled positive pressure ventilation is the recommended technique for robotic surgery. This can be explained by the long duration of the procedure, the extreme positions, the need to insert nasogastric or orogastric tubes and the need for muscle relaxation. The need for muscle relaxation is extremely important for robotic surgery as the increased intra-abdominal pressure with splinting of the diaphragm makes spontaneous breathing difficult. Moreover, any patient movement after docking the robot could lead to outrageous consequences. Also, muscle relaxation is useful to allow augmentation of ventilation to decrease levels of CO_2 associated with abdominal insufflation [5].

The successful use of laryngeal mask (LMA) in some short laparoscopic procedures has been reported. However, the limited capability of applying positive pressure ventilation and the insecure guarding against aspiration in robotic surgery contraindicates its usage in robotic surgery [18].

Regional anaesthesia alone could be used successfully in laparoscopic surgery, but it is impossible to use alone in robotic surgery due to the positioning, the high sensory block level required, and the hyperventilation required to maintain a normal level of CO_2. Besides, the patient's tolerance to a long procedure such as robotic surgery is questionable. Regional anaesthesia can be combined with general anaesthesia for pain relief. However, it should be kept in mind that the sympathetic response to abdominal insufflation, which maintains the blood pressure and cardiac output, will be abolished by regional anaesthesia [19, 20].

Any combination of anaesthetic agents that provides amnesia, analgesia, and paralysis could be used. The use of antiemetics is recommended, as peritoneal stimulation and distension will increase the risk of postoperative nausea and vomiting (PONV). A combined use of antiemetics of different mechanisms of action is advised. The choice between inhalational anaesthetics and total intravenous anaesthesia (TIVA) is operator-dependent as long as guarding against awareness is kept in mind using the required level of monitoring (end-tidal inhalational level and/or Bispectral Index). The use of nitrous oxide is controversial due to its diffusion capability, bowel distension causing more difficulties in surgery and postoperative nausea and vomiting [7].

3.2 Monitoring and access

The level of monitoring for robotic surgery can differ from one patient to another depending on the patient's comorbidities, degree of complexity, and length of surgical procedure and expected blood loss. Generally speaking, many anaesthetists prefer invasive arterial lines for monitoring blood pressure and frequent gas analysis besides the standard monitoring (ECG, oximeter, capnogram, inspired O_2 fraction, end-tidal inhalational anaesthetic, minute ventilation, peak airway pressure, urine output, and oesophageal temperature monitor). However, it should always be kept in mind that access to the patient during surgery is extremely limited. So, lines should always be secured with extra caution. Line kinking, displacement, and obstruction are common issues during robotic surgery due to the fact that access is limited,

DOI: http://dx.doi.org/10.5772/intechopen.1004191

especially after docking of the robot. EEG monitoring is preferable in some conditions when there is a risk of postoperative cognitive dysfunction to avoid unnecessarily deep levels of anaesthesia.

Usually, standard IV access with wide-bore cannulae would be enough to maintain anaesthesia and intraoperative fluid therapy. However, central venous pressure (CVP), pulmonary artery pressure, pulmonary artery occlusion pressure (PAOP), and cardiac output should be used in some patients depending on their comorbidities [21–23].

3.3 Positioning

Positioning in robotic surgery is one of the major factors that affects patient condition. In robotic surgery, extreme forms of Trendelenburg and reverse Trendelenburg are not uncommon. Also, it should be kept in mind that changing the position after docking the robot is difficult. The position effect on patient health can be summarised as follows [7]:

- Respiratory: movement of endotracheal tube and bronchial intubation, airway oedema, atelectasis, aspiration.
- Cardiovascular: reduced venous return and hypotension.
- Central nervous system: cerebral and conjunctival oedema, C5-7 disruption.
- Peripheral nervous system: compression on various nerves depending on position, neuropraxia, neuropathy.
- Gastrointestinal: increased risk of reflux and mouth ulcers (from acid reflux).
- Musculoskeletal: pressure sores, compartment syndrome.

Measures to avoid complications related to position can be summarised as follows [7]:

- Delicate positioning with gel padding, straps with support and avoidance of stretching of limbs and compression stocking.
- Good securing of the cuffed endotracheal tube with a recheck of its position after patient positioning and avoidance of tight ties. Check the cuff pressure after inflation and consider a leak test before extubation.
- Usage of positive end-expiratory pressure (PEEP).
- Insertion and drainage of nasogastric tube.
- Preload the patient with fluids, make judicious fluid intake, and consider the usage of vasopressors before positioning.
- Periodic checking of the patient face.

3.4 Ventilation

Lung protective ventilation has been suggested for ventilation in robotic surgery. However, there is no available data for the best PEEP level to be used. High PEEP levels would provide better lung aeration. On the other hand, it will negatively affect blood pressure and increase the risk of barotrauma and alveolar overdistension. Lower PEEP levels will avoid these problems. Various studies tried to find the best PEEP level. From these studies, we can conclude that zero-end expiratory pressure should be avoided, and moderate PEEP levels (4–8 cmH_2O) have been associated with better outcomes than high PEEP levels (>10 cmH_2O). However, an individualised PEEP level is optimal [24].

No specific data is available to define the best mode of ventilation independently from other ventilatory parameters. It is suggested to set the tidal volume to 6–8 ml/kg of predicted body weight with a PEEP level of 4–8 cmH_2O. However, it is suggested to use pressure-controlled ventilation with a monitor of tidal volume to avoid barotrauma and better gas exchange. Inspiratory:expiratory ratio of 2:1 or 1:1 has been found to improve CO_2 clearance through decreasing dead space fraction. Although prolonged inspiratory time has been found beneficial for acute lung injury patients by improving oxygenation, no such effect has been noticed in robotic surgery [25].

Recruitment manoeuvres are frequently used to decrease atelectasis, improve alveolar ventilation, and decrease intrapulmonary shunting. However, it might decrease venous return and lead to barotrauma and alveolar overdistension. It is better to be used in case of hypoxemia or deterioration of respiratory mechanics during or after pneumoperitoneum [26].

3.5 Intravenous fluids

IV fluid management in robotic surgery is an art balance between maintaining perfusion and preventing volume overload. Recent surgical practice results in euvolemic patients preoperatively by carbohydrate loading, reduced bowel preparation, and reduced fluid fasting hours.

A relatively new concept in fluid management is introduced depending on the delivery of O_2 (DO_2) divided by body surface area to produce indexed oxygen delivery (DO_2I) measured by ml/min/m^2. Multiple literature can be found supporting the idea that maintaining high DO_2I has an effect on decreasing morbidity and mortality in open surgeries. However, the effect of robotic surgeries needs further investigation [27].

The advised approach to fluid management is [5]:

- Fluid replacement for pre-existing fluid deficit if present.
- Targeting zero fluid balance with maintenance around 1–4 ml/kg/h and replacement of measured losses.
- Intraoperative hypotension should be managed with vasopressors rather than fluids unless it is due to hypovolemia.

- Monitoring of urinary output is required, especially in prolonged complex robotic surgery. Permissive oliguria with urine output of 0.3 ml/kg/h is widely adopted without affection of renal function.

- CVP is inaccurate in the management of fluid balance due to the extremes of position and pneumoperitoneum. Other markers such as serum lactate, acid-base balance, and central venous oxygen saturation provide better monitoring of fluid status.

The increased risk of cerebral oedema, especially in extreme Trendelenburg positions, should always be kept in mind while managing the fluid status of the patient.

3.6 Analgesia

Multimodal analgesia with opioid-sparing drugs is the new trend in the analgesic management of surgical operations. Large doses of opioids are associated with a higher incidence of postoperative nausea and vomiting, suppression of cough reflex, delay in return of gastrointestinal (GIT) function, and higher risk for opioid misuse [28].

Epidural analgesia for such operations was considered the gold standard for a long time. However, due to causes related to delayed return of GIT function, reduced mobility, increased fluid requirement, and increased hospital stay, the use of epidural analgesia is declining when compared with single-shot spinal anaesthesia and morphine PCA [29].

A popular method of injection of 250–1000 mcg of intrathecal diamorphine with regular postoperative paracetamol and non-steroidal anti-inflammatory drugs (NSAIDs), unless contraindicated, is used with reserving of opioid use to breakthrough pain [5]. The usage of other regional techniques such as transversus abdominis block (TAP), especially before the operation starts was successful. Some practitioners use remifentanil infusion to manage some physiological responses during surgery. However, there are still some concerns about tolerance and hyperalgesia [30].

The second line of analgesics using IV ketamine and lidocaine is currently under focus, especially for IV lidocaine and its role in decreasing postoperative nausea and vomiting and opioid use. However, the exact timing, dosing, and duration of IV lidocaine are still inconclusive [31, 32].

3.7 Muscle relaxants

Muscle relaxation in robotic surgery is mandatory to prevent patient coughing and movement. Multiple comparisons between a deep level of relaxation (post-tetanic count of one to two twitches) and a moderate level of relaxation (train of four of one to two twitches) have been made. Theoretically, a deep level of relaxation will provide better surgical conditions with lower intra-abdominal pressure (8–15 mmHg). However, the difference between the two levels is still not obvious [5].

3.8 Antiemetics

Usage of multi-modal antiemetics in robotic surgery is advised due to the higher risk of postoperative nausea and vomiting associated with robotic surgery [5].

4. Intraoperative complications of robotic surgery

4.1 Cardiovascular complications

Cardiovascular complications during robotic surgery could be generally considered uncommon. Bradycardia that might develop asystole due to abdominal insufflation is the commonest [33]. Other complications include arrhythmia, atrial fibrillation, bundle branch block, cardiogenic pulmonary oedema, and, less commonly, myocardial ischaemia and infarction [34–36].

4.2 Vascular complications

The most devastating vascular complication related to robotic surgery is lower limb compartment syndrome, with an incidence of 0.02%. The management is usually fluid resuscitation and analgesics, and sometimes might need bilateral fasciotomy. Lower limb compartment syndrome could be explained by increased intra-abdominal pressure, lithotomy position, and Trendelenburg position that led to decreased blood flow to lower limbs [11].

Venous gas embolism is one of the common vascular complications of robotic surgery with an incidence of 7–10%. However, mostly, it has no cardiovascular effect or other sequelae. That could be explained by the Trendelenburg position and increased right atrial pressure that guards against the haemodynamic effect [11].

Other vascular complications include deep venous thrombosis, vascular injury, especially during port insertion, and rhabdomyolysis, which is commonly associated with compartment syndrome [11].

4.3 Cardiac arrest and robot failure

Please refer to chapter (Perioperative considerations for patients undergoing robotic radical prostatectomy).

5. Postoperative complications of robotic surgery

The advantages of robotic surgery cannot be ignored. On the other hand, with the emergence of robotic surgery, multiple changes and complications were noted affecting all systems of the human body. Complications were noted from case reports and case series after the introduction of robotic surgery. It could be categorised according to the system affected:

5.1 Neurological complications

Most complications related to robotic surgery are neurological, and a good percentage of them are related mainly to positioning. It could be further subdivided into central and peripheral nervous system complications [11].

Cerebral oedema is the main central nervous system complication. It could lead to a postoperative altered mental state that sometimes needs reintubation. Cerebral oedema is related to the Trendelenburg position and increased intra-abdominal pressure. Both factors would lead to increased central venous pressure and capillary leak. Preventive measures could be limiting time for steep Trendelenburg position, limiting operative time, fluid restriction, and limiting intra-abdominal pressure to 8 mmHg as possible. Cerebral oedema could be managed using dexamethasone and diuretics [37–40].

Peripheral nerve damage is relatively uncommon but devastating, commonly related to steep Trendelenburg position and long operative time. The mechanism of injury could be explained by stretch, ischaemia, and compression. The overall incidence of peripheral nerve injury in robotic surgery is 0.25% [41].

Upper extremities nerve injury is mainly brachial plexus injury with an incidence of 20% of all peripheral nerve injuries. The most common nerve injury is ulnar nerve followed by the brachial plexus and median nerve. The injury could be related to pressure over acromioclavicular joints. Fortunately, most upper extremity injuries have no long-term sequelae and resolve spontaneously within a few weeks [42–48].

Lower extremity nerve injury could be related to steep Trendelenburg with lithotomy position. This position could lead to compression of the peroneal nerve between head of fibula and leg support and compression of the saphenous nerve against the medial tibial condyle. Furthermore, other lower limb nerves could be affected by this position such as obturator nerve, common peroneal nerve, sciatic nerve, and lateral femoral cutaneous nerve. Lower limb nerve injury incidence ranges between 0.3% and 5.1% [49–51].

5.2 Ophthalmic complications

The most common ophthalmic complication is corneal abrasion which could be related to incomplete coverage of the eye and conjunctival oedema. Other complications include ischaemic optic neuropathy and various degrees of visual field affection and blindness [11].

5.3 Pulmonary complications

Pulmonary complications related to robotic surgery could be summarised in basal atelectasis as a result of abdominal insufflation and Trendelenburg position, hypoxemia due to migration of endotracheal tube to the right main bronchus, aspiration with microaspiration being more common, airway oedema, and pneumothorax [11].

5.4 Renal complications

Renal complications ranged from mild elevation of renal function up to acute kidney injury (AKI). The incidence of acute kidney injury in robotic surgery versus open surgery is still controversial. Acute kidney injury could be noted in the form of oliguria <0.5 ml/kg/h for >6 hours or elevation in serum creatinine. Acute kidney injury could be explained by elevated abdominal pressure, which leads to increased renal vascular resistance being more common in the elderly. Others suggest that the reason could be rhabdomyolysis and compartment syndrome. Oliguria without clinical manifestations has been reported and could be attributed to renal compression [52–57].

5.5 Gastrointestinal complications

Few complications were noted in the gastrointestinal system and could be considered nonspecific to robotic surgery. One case report of acute hepatic injury could be explained by increased intra-abdominal pressure leading to portal ischaemia. Small bowel and colon damage during port insertion has also been reported [58, 59].

5.6 Musculoskeletal complications

Musculoskeletal complications could be divided into trauma, subcutaneous emphysema, and oedema. Trauma has been noticed in multiple areas of the body including face, digits thigh, flanks, oral ulceration, and subconjunctival. Cervical and lumbar strain was also noted without long-term sequelae, though. Moreover, pressure sores are reported commonly in the gluteal area with various degrees, and vacuum mattresses should be considered, especially in prolonged procedures [11].

Subcutaneous emphysema has been reported relatively frequently. Some reports referred to mediastinal emphysema but without long-term effects. Risk factors for developing subcutaneous emphysema could be prolonged operative time, increased $etCO_2 > 5.3$ kPa and more than five surgical ports [11].

Postoperative conjunctival oedema is very common, and some consider it a common effect of steep Trendelenburg. Significant oedema in multiple body parts was also noted in a fair number of cases, while the incidence of head and neck oedema reached 12%, which could lead to airway oedema and delay of extubation and, in some cases, reintubation [11].

6. PROSPECT guidelines for postoperative pain management in radical prostatectomy

Procedure-specific postoperative pain management (PROSPECT) is a guideline developed by a group of anaesthetists and surgeons in order to manage postoperative pain in radical prostatectomy (open, laparoscopic, or robotic) and is updated based on systematic review and meta-analysis. M. Lemoine and colleagues published PROSPECT guidelines in Anaesthesia and Critical Care Medicine, 2021 that concluded [60]:

1. Comprehensive pain relief should involve the administration of paracetamol and either selective or non-selective nonsteroidal anti-inflammatory drugs before or during surgery, with ongoing postoperative continuation.

2. During open surgery, it is advisable to employ continuous intravenous lidocaine. However, its usage contradicts the concurrent use of local anaesthetics through infiltration.

3. In the absence of intravenous lidocaine usage, local wound infiltration should be routinely employed for open surgery before considering other regional analgesia blocks.

4. For laparoscopic/robotic radical prostatectomy, it is recommended to prioritise the Transversus Abdominis Plane block as a plan of analgesia.

5. In the postoperative period, opioids are recommended for use as rescue analgesics.

7. Conclusion

The emergence of robotic surgery might someday change the shape of medicine that we know. The advantages of robotic surgery outweigh its drawbacks. Being a relatively new technique, robotic surgery is still under continuous development. Anaesthetic management of robotic surgery could be challenging given the physiological changes related to position, duration of surgery, and abdominal insufflation. Various anaesthetic techniques have been developed to manage such cases. However, complications of robotic surgery could not be ignored, and the ultimate aim for anaesthesia is to provide a safe patient journey through the surgery.

Acknowledgements

The authors would like to thank Southend University Hospital NHS Trust for providing an image of the Di Vinci robotic system.

Conflict of interest

The authors declare no conflict of interest.

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