Robotic Surgery

48

Kyle Smith and Raymond M. Planinsic

The practice of surgery continues to evolve as physicians advance surgical techniques to improve patient outcomes and safety. Patients with significant medical comorbidities often present to the operating room, in whom anesthetic management and postoperative recovery are usually more complicated. Minimally invasive surgery is becoming the standard of care in these patients, and robotic-assisted surgery can be considered as an evolution of minimally invasive surgery. Robotic surgery has several anticipated benefits and disadvantages as listed in Table 48.1. As more surgeries evolve into robotic-assisted surgeries, anesthesiologists should have a basic knowledge of the procedures as well as the robotic devices in order to formulate an anesthetic plan and provide appropriate patient care.

History

The first minimally invasive surgery was a laparoscopic cholecystectomy that was performed in 1987. Since then, laparoscopy has gained widespread acceptance, and today it is used in a wide variety of procedures. The current technology behind robotic surgery was aided largely by the United States Army (Department of Defense). They desired a system that would allow surgeons to treat soldiers on the battlefield from a safe distance, that is, the concept of telerobotic surgery. The technologies of telerobotic surgery and laparoscopic surgery were eventually developed into two tele-manipulative robotic systems, the da Vinci Robotic Surgical System and the Zeus Robotic Surgical System. The two systems were developed in parallel until the manufacturer of the da Vinci system (Intuitive Surgical) acquired the rights to the Zeus robotic system. They continue to support existing Zeus robotic systems which are still used in Europe and other countries. The only full-scale robot system available and currently in use in the United States is the da Vinci system.

Today robotic assistance is being used in a wide variety of surgeries and specialties including urologic, cardiac, thoracic, otorhinolaryngologic, orthopedic, gynecologic, and pediatric surgery (Table 48.2). The first robotic-assisted surgery was performed by Kwoh et al., who used the PUMA 560 to perform neurosurgical biopsies. Internal mammary artery harvesting was successfully performed thoracoscopically by Nataf in 1997. The first reported endoscopic coronary artery bypass surgery was performed in 1998 by Loulmet. Since then, robotic-assisted cardiac surgery has expanded to include mitral valve repairs, patent ductus arteriosus ligations, and atrial septal defect closures. As of 2008, more than 80,000 robotic procedures have been performed.

The Robot

The da Vinci robot (Fig. 48.1) consists of three main parts: the master console, an optical tower, and the surgical cart. The control console is where the surgeon sits and controls the robot. It consists of a 3-D screen that projects an image from the intraoperative camera. The surgeon controls the robot using hand controls, three robotic arms, and foot pedals. The right and left hand controls control the right and left arms of the robot respectively, while the third arm controls the endoscopic camera. Foot pedals control electrocautery and ultrasonic instruments and adjust the camera.

The robotic system allows for ergonomic anatomic control of the instruments which mimic the movement of the human wrist. The instruments have seven degrees of motion

K. Smith, M.D. • R.M. Planinsic, M.D. (✉)
Department of Anesthesiology, University of Pittsburgh Medical Center, 200 Lothrop Street, Suite C-200, Pittsburgh, PA, USA
e-mail: planinsicrm@anes.upmc.edu

P.K. Sikka et al. (eds.), *Basic Clinical Anesthesia*,
DOI 10.1007/978-1-4939-1737-2_48, © Springer Science+Business Media New York 2015

Table 48.1 Advantages and disadvantages of minimally invasive/robotic surgery

Advantages	Disadvantages
Technical precision	Loss of force and tactile perception
Less pain	Decreased natural hand-eye coordination
Less blood loss	Fixed/immobile robot
Smaller incisions and better cosmetic results	Effects of CO_2 insufflation
Faster recovery and shorter hospital stay	Expensive and new technology
Less risk of infection	Large size of the system
Better postoperative immune function	

Table 48.2 Examples of robotic-assisted surgeries

General surgery	Cholecystectomy, gastric bypass, bowel resection
Urologic surgery	Radical prostatectomy, nephrectomy
Gynecology	Hysterectomy, tubal reanastomosis
Orthopedic surgery	Hip arthroplasty, knee and spine surgery
Neurosurgery	Image-guided surgery
Cardiothoracic surgery	Coronary artery bypass graft, mitral valve repair, mammary artery harvesting

versus four degrees of motion with the standard laparoscope. The robotic system has motion scaling that can be adjusted from 1:1 up to 5:1 that allows the system to be set up to compensate for surgeon's hand tremor and when required a larger movement by the surgeon for a smaller movement in the operating field. The optical tower projects the images from the field and displays it for the operating room and also has the capability to record. The surgical cart, or robot itself, has 3–4 arms and must be manually wheeled in close vicinity to the patient.

Anesthetic Considerations

Robotic surgery produces some unique challenges, and the anesthesiologist should be aware of these in order to provide the safest patient care. A few issues related to robotic surgery are patient positioning, hemodynamics, hypothermia, blood loss, and the effects of pneumoperitoneum.

Patient positioning is important in every case and is a task for which the anesthesiologist and surgeon are both responsible. This is all the more important when dealing with robotic-assisted procedures. Some robotic cases can be lengthy depending on the complexity of the case and the learning curve of the surgeon. Therefore, careful attention should be paid to padding position points as well as securing the patient to the bed. The patient's airway may be some distance from the anesthesiologist and should be secured accordingly. In certain cases, the patient may even be 180° from the anesthesiologist and the monitors.

The robot is large and must be docked in close vicinity to the patient, and *access* to the patient after it is docked can be very limited. Depending on the complexity of the case and the history of the patient, the anesthesiologist should consider additional intravenous (IV) access since obtaining additional IV access once the procedure has commenced may be extremely difficult. Most cases will require two IVs, and if an arterial line is required, it must be inserted at the start of the case. Once the patient is positioned, the anesthesiologist may not have access to the arms.

The *position of the robot* in relation to the position of the patient is just as important. The robot has 3–4 arms that move with some force in relation to the surgeon's movements. The surgeon has some tactile feel from the operative site but is not aware of how the arms move in relation to the patient, which is one aspect of robotic surgery that is different from other laparoscopic procedures. If a brisk movement of the arm was to contact the patient, it could injure the patient. Therefore, the patient, especially the face and arms, must be clear of the range of motion of the robot arms. Cameras and light sources should be monitored and never left in direct contact with the drapes or the patient for risk of fire and injury to the patient. The staff in the room must be trained on dismantling the robot and moving it in the quickest fashion in order to gain access to the patient in case of an emergency.

Once the robot is engaged and the surgical instruments are within the patient for the operation, *muscle paralysis* of the patient is of utmost importance, as patient movement can be detrimental both to the patient and the robot, which is fixed. Muscle relaxation with a non-depolarizing neuromuscular agent is critical to the anesthetic plan. Anesthesia can be maintained with an oxygen-air mixture and a volatile agent with or without the combination of an intravenous agent.

Carbon dioxide *insufflation* is routinely used intraoperatively, which can have many hemodynamic effects. It increases systemic vascular resistance, filling pressures, and mean arterial pressure. Central venous pressure and pulmonary capillary wedge pressure may rise during pneumoperitoneum. Pneumoperitoneum can cause a decrease of pulmonary compliance by 30–50 % secondary to diaphragmatic elevation. Also, an increase in minute ventilation may be necessary to compensate for the increase in $PaCO_2$.

Emergence and neuromuscular blockade reversal should be delayed until the robot is completely disengaged and removed from the patient. Pain medication requirement and intraoperative blood loss for robotic-assisted surgeries are generally decreased when compared to traditional open procedures.

Robotic surgery, although still in its infancy, is set to revolutionize surgery by improving laparoscopic procedures and

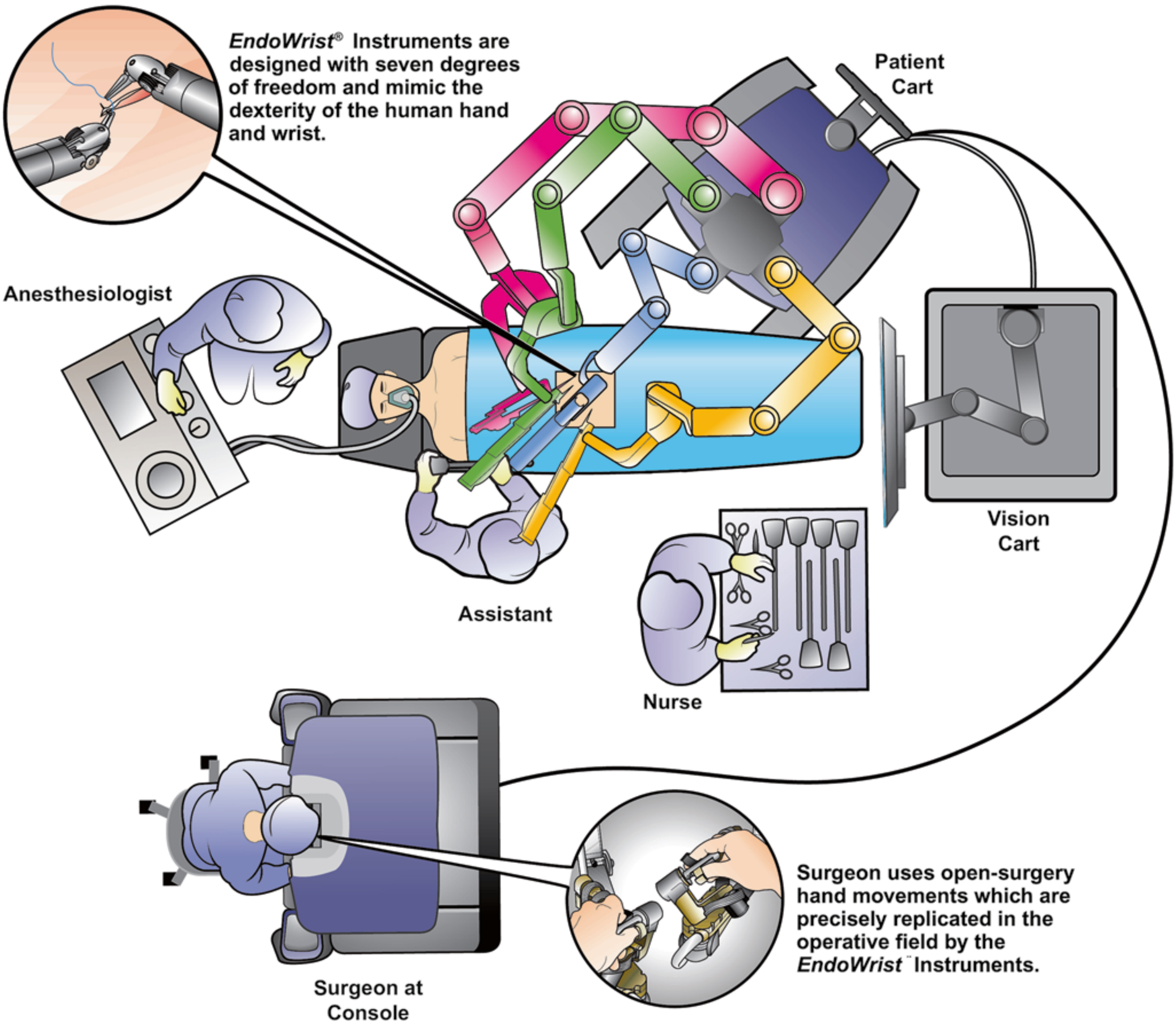

Fig. 48.1 General operating room setup of the da Vinci robotic system (courtesy Intuitive Surgical, Inc.)

bringing surgery into the digital age. Robotic surgery has the potential to advance surgical procedures beyond human capabilities, though high costs remain a significant hindrance factor. The anesthesiologist should be aware of the complex equipment as well as specific anesthetic considerations in order to formulate a plan for optimal patient health and safety. Patient positioning is extremely important, and specific attention should be made to padding pressure points. The position of the robot in respect to the patient should be noted, and securing the airway is of prime importance. Movement of the robotic arms should be clear of the patient, and therefore, patient paralysis is important to prevent unintentional harm to the patient. As technology and surgeon's learning curve improve in the area of robotic-assisted surgery, the anesthesiologist must stay current and adjust their anesthetic plan accordingly.

Clinical Review

1. Compared to traditional open surgeries, robotic-assisted surgeries have
   A. Similar blood loss
   B. Similar pain medication requirements
   C. Similar cosmetic results
   D. Faster recovery times
2. All of the following are true statements regarding robotic-assisted surgery, EXCEPT
   A. The robot is large and once in place is fixed in position.
   B. Air is used for intraoperative insufflation.
   C. The operating room size generally has to be bigger to accommodate the robot.
   D. The surgeon has loss of touch sensation while performing the surgery.

3. A 58-year-old patient is undergoing a robotic-assisted radical prostatectomy under general anesthesia. Anesthesia is best maintained by
   A. Oxygen, nitrous oxide, and an inhalational agent
   B. Oxygen, air, and an inhalational agent
   C. Oxygen, air, inhalational agent, and a muscle relaxant
   D. Oxygen, air, inhalational agent, and a propofol infusion

Answers: 1. D, 2. B, 3. C

Further Reading

1. Bodner J, Augustin F, Wykypiel H, et al. The da Vinci robotic system for general surgical applications: a critical interim appraisal. Swiss Med Wkly. 2005;135(45–46):674–8.
2. Chauhan S, Sukesan S. Anesthesia for robotic cardiac surgery: an amalgam of technology and skill. Ann Card Anaesth. 2010;13:169–75.
3. D'Attellis N, Loulmet D, Carpentier A, et al. Robotic-assisted cardiac surgery: anesthetic and postoperative considerations. J Cardiothorac Vasc Anesth. 2002;16:397–400.
4. Himpens J, Leman G, Cadiere GB. Telesurgical laparoscopic cholecystectomy. Surg Endosc. 1998;12:1091.
5. Morgan JA, Peacock JC, Kohmoto T, et al. Robotic techniques improve quality of life in patients undergoing atrial septal defect repair. Ann Thorac Surg. 2004;77:1328–33.
6. Suematsu Y, Mora BN, Mihaljevic T, et al. Totally endoscopic robotic-assisted repair of patent ductus arteriosus and vascular ring in children. Ann Thorac Surg. 2005;80:2309–13.
7. Talamini M, Campbell K, Stanfield C. Robotic gastrointestinal surgery: early experience and system description. J Laparoendosc Adv Surg Tech A. 2002;12:225–32.