# 9 Anesthetic Considerations and Management

Christopher L. Yerington and Barry Nuechterlein

The advancement of surgery into the digital and computer-assisted era has generated a new amalgamation of known anesthetic challenges. This chapter is designed to provide both surgeons and anesthesiologists with a quick reference, guiding optimal peri-operative care in patients receiving robotic urologic surgery. In addition, information critical to ensuring patient safety when utilizing computer-assisted surgical techniques is discussed.

The patient population served in most robotic urologic surgeries where computer assistance is being utilized consists of males, aged 45 to 75 years old, ideally with minimal physiologic perturbations due to underlying disease. Laproscopic considerations mostly revolve around the effects of insufflation of the abdominal cavity and the surgical site being less accessible than during open procedures. Robotic and positioning considerations would include the critical importance of maintaining patient paralysis and the physiologic implications of placing a patient in a high degree of Trendelenburg's position. Generally, the patient's recovery is similar to that of all patients receiving laproscopic surgery and adequate pain management is easily achieved by utilizing multiple modalities (see Figure 9.1).

## 9.1. Patient Population

In order to provide adequate anesthesia for these procedures, an awareness of the nature of the patients involved is imperative. Males, aged 45 to 75 years old, have a variety of predictable medical issues of concern to the anesthesiologist. In western societies, the prevalence of obesity, diabetes, hypertension, underlying coronary artery disease, and/or peripheral vascular disease necessitates obtaining an adequate history and physical. Ideally, this should be accomplished prior to the day of surgery to ensure any laboratory or functional data can be collected, reviewed, and acted upon.

For example, obesity and hypertension have increasing prevalence with advancing age.[1] Based on data collected in 1999 and 2000, the U.S. National Center for Health Statistics (NCHS) reported in 2003 that 30.1% of men aged 45 to 54 are obese, 32.9% of men aged 55 to 64 are obese, 33.4% of men aged 65 to 74 are obese, and 20.4% of men aged over 75 are obese. Similarly, the same publication reports 36.9% of men aged 45 to 54 have hypertension, 50.7% of men aged 55 to 64 have hypertension, 68.3% of men aged 65 to 74 have hypertension, and 70.7% of men aged over 75 have hypertension. Although nothing can be done about a patient's obesity on or near the date of surgery, a patient's hypertension can be medically optimized prior to surgery.

Obesity presents a variety of direct and indirect challenges to the anesthesiologist.[2] In addition to its contribution to hypertension, coronary artery disease, and diabetes, obesity has direct physical and physiologic implications in patients receiving computer-assisted robotic laparoscopic procedures. Most important among these implications are the effects on pulmonary physiology.[3] When a patient with a large volume of abdominal contents, adipose mass, and central girth is placed in

**Figure 9.1.** Dr. Patel with a patient prepped, draped, and positioned during engagement of da Vinci® robotic system.

steep Trendelenburg's position with a pressurized pneumoperitoneum, a substantial hindrance to normal diaphragmatic excursion can be generated. This hindrance, in addition to the patients' body habitus, creates both a restrictive pulmonary deficit and atelectasis, with its resultant shunting. Hypercapnia can be seen due to the difficulty of achieving adequate minute ventilation and hypoxia secondary to atelectasis-based shunting are examples of the consequences of these physiologic disruptions and must be avoided.

Hypertension is characterized by increased afterload and decreased intravascular volume. Management of anesthesia in the hypertensive patient begins with preoperative evaluation to determine adequacy of blood pressure control, pharmacologic antihypertensive agents utilized, and presence of end-organ dysfunction.[4] The presence of orthostatic hypotension, ischemic heart disease, cerebrovascular disease, peripheral vascular disease, and/or renal dysfunction should be uncovered. The anesthetic plan will need to incorporate adjustments for these disease states. Also, during induction of anesthesia in the hypertensive patient, one should attempt to minimize the duration of laryngoscopy and expect exaggerated blood pressure fluctuations secondary to vasodilation.[5] The anesthesiologist should modify the dosage of volatile anesthetic to control blood pressure and compensate for any changes in patient position.

Postoperative management of the hypertensive patient includes anticipation of hypertension unrelated to pain and its adequate treatment. Continuation of monitoring modalities utilized intraoperatively in the immediate postoperative period enables a prompt response to blood pressure fluctuations. Signs of myocardial ischemia can be concealed by pain medications and overt use of antihypertensive medication. Vigilance must be maintained during the immediate postoperative period.

Diabetes is an illness that can affect a multitude of organ systems and has many predisposing factors.[6] Aside from the principal goals of maintaining good glycemic control and avoiding ketoacidosis and electrolyte disturbances, the anesthesiologist must appreciate the implications of diabetic autonomic neuropathy. Common manifestations of diabetic autonomic neuropathy include orthostatic hypotension, resting tachycardia, and gastroparesis.[6] As mentioned elsewhere, the combination of a pneumoperitoneum and the placement of the patient in a physiologically challenging position will have perturbing effects on hemodynamics. These effects may be greatly exaggerated in the patient with diabetic autonomic neuropathy.

While no consensus exists on how tightly to maintain glycemic control or otherwise optimize medical management of the diabetic patient in the peri-operative period, discussions are ongoing.[7] A recommendation from 1991, published in *Anesthesiology*, is to maintain the blood glucose concentration in the range of 120 to 180 mg/dL.[8] As in many areas of anesthetic management, attempting to maintain a normal physiologic state is always desirable.

There are many specific anesthetic concerns relating to a patient with coronary artery disease and other vascular disease undergoing any surgical procedure requiring general endotracheal anesthesia. There exist a variety of risk factors for coronary artery disease and other vascular diseases. Obesity, hypertension, diabetes, advanced age, smoking, male gender, family history, stress, inactivity, and high cholesterol are widely recognized as predisposing factors for development of such illnesses.[9] Clinicians should be mindful of these issues, as these illnesses influence the risk of anesthesia and surgery. Peri-operative evaluation, planning, and optimization should be conducted in such a manner as to minimize these risks.

To provide adequate anesthesia for these procedures, an awareness of the nature of the patients involved is imperative. The prevalence of obesity, diabetes, hypertension, coronary artery disease, and/or peripheral vascular disease necessitates obtaining an adequate history and physical. Prior to the day of surgery, any laboratory or functional data should be collected, reviewed, and acted upon. These patients have a variety of predictable medical issues of concern to the anesthesiologist.

## 9.2. Laparoscopic Considerations

Next year, laparoscopic surgery will be entering its third decade of general use. Increasing interest in laparoscopy among general surgeons developed in 1987 after the French gynecologist Mouret performed the first acknowledged laparoscopic cholecystectomy by means of four trocars.[10] Operative laparoscopy has advanced surprisingly since 1990. Laparoscopic surgery is now entering a phase of slower development. Refinements of laproscopic techniques will come as evolutionary changes in instrumentation and practice rather than an inventive revolution.[11] However, computer-assisted robotic surgery utilizing minimally invasive techniques is rapidly developing towards real-time remote surgery. Clearly, this represents a revolutionary development with extensive implications for the anesthesiologist.

The pulmonary physiologic consequences of intraperitoneal insufflation include decreased compliance, decreased functional residual capacity, and increased shunting due to atelectasis.[12] Principal complications include subcutaneous emphysema, pneumothorax, gas embolism, and cephalad shift of the diaphragm, resulting in inadvertent endobronchial intubation. Because carbon dioxide ($CO_2$) is the most common gas utilized for insufflation, it is appropriate to discuss its physiologic peculiarities. These include $CO_2$ absorption, resulting in hypercapnia; potential vasodilation (including cerebral vasodilation); increased metabolism; and increased likelihood of spontaneous respirations in spite of adequate depth of anesthesia.[12]

The cardiac and hemodynamic effects of pneumoperitoneum include decreased cardiac output, elevation of arterial pressures or systemic vascular resistance, and increased pulmonary vascular resistance. It is important to note that decreases in cardiac output are proportional to the increase in intraabdominal pressure.[13] There is some evidence that cardiac output changes little with intraperitoneal insufflation. However, when this is coupled with steep Trendelenburg's position, most studies show a fall of between 10% and 30% in cardiac output.[14] The decrease in cardiac output is secondary to decreased venous return from caval compression and dependent venous pooling. This decrease can be somewhat mitigated by normalizing the circulating volume prior to insufflation, or by utilizing less Trendelenburg's position.

An additional physiologic concern during laparoscopic procedures, particularly those of long duration performed in steep Trendelenburg's position, is the effect of positioning and abdominal insufflation on the nervous system generally and intracranial pressure (ICP) specifically. In patients with ventriculoperitoneal (VP) shunts, it is important that the clinician be attentive to function of the shunt postoperatively, as shunt malfunctions in the wake of surgical pneumoperitoneum have been reported.[15] If a patient is suspected of having elevated intracranial pressure, insufflation of the abdomen (with likely resultant increase in central venous pressure and decreased cerebral perfusion pressure) can be detrimental.[16]

Generally, American Society of Anesthesiology (ASA) standard monitoring is adequate for most computer-assisted robotic laparoscopic procedures. If the nature of the procedure or patients condition warrant placement of invasive monitoring, it should be strongly considered. The reason it should be considered prior to any robotic surgical intervention is because the patients position relative to the robot precludes easy placement of these monitors during the procedure. Additionally, it should be appreciated that there might be no opportunity to achieve better vascular access for resuscitation or monitoring after starting the robotic portion of the procedure (see Figure 9.2).

The recommended anesthetic technique for most laparoscopic procedures, especially those involving a great deal of head-down positioning, involves endotracheal intubation during general

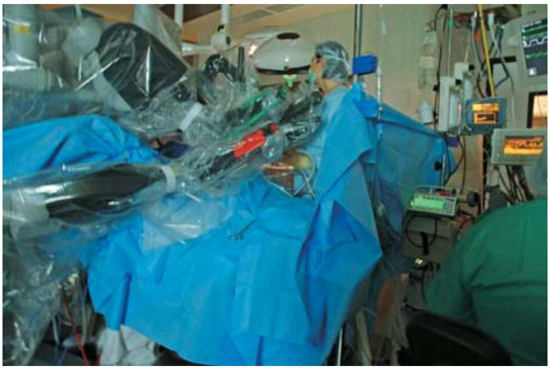

**FIGURE 9.2.** Depiction of patient undergoing computer-assisted robotic prostatectomy with very limited patient access.

anesthesia. According to a report from the Centers for Disease Control (CDC), one third of the deaths associated with a subset of laparoscopic procedures (tubal ligations) in the period from 1977 to 1981 were related to anesthetic complications during anesthesia without intubation.[17] Given the limitations of positive pressure ventilation in a relaxed patient without an endotracheal tube, attempting to administer anesthesia without one in this context seems daunting. Also particularly important during robotic procedures involving trocars fixed to a stationary device, the patient must *always* remain adequately relaxed.[18] In subsequent portions of this chapter, there will be further discussion of one method of ensuring complete and reliable relaxation during these procedures. A variety of agents may be used to achieve adequate amnesia, analgesia, and relaxation. Nitrous oxide may cause distention of bowel, presenting added technical difficulty in intestinal surgeries, but its use has not otherwise been shown to generate substantial clinical disadvantage.[19]

In summary, laparoscopic techniques result in multiple benefits to the patient, including reduced trauma and postoperative pain, quicker recovery, and overall shorter hospital stays. While many types of procedures can benefit from laparoscopic techniques, minimally invasive urologic surgery seems to have surprising benefits compared to open techniques. The death rate during operative laparoscopy is 1 per 1000 cases; the incidence of hemorrhagic or visceral injury–related complications is approximately 3 per 1000. General anesthesia with controlled ventilation seems to be the safest technique for operative laparoscopy.[20]

## 9.3. Robotic/Positioning Considerations

There are some substantial differences between conventional laparoscopic surgery and computer-assisted robotic laparoscopic surgery. A discussion of those differences provides useful illumination to improve the clinician's understanding of this latter group of procedures. In addition, pictorial references are helpful when describing robotic and positioning considerations. These differences include challenges relating to patient access, the critical importance of adequate and sustained relaxation through the entire robotic phase of the procedure, and the challenges of physically securing and protecting the patient to prevent sliding or shifting when the robot is engaged. The photographs to follow are from a computer-assisted robotic prostatectomy, during which a steep Trendelenburg position was utilized.

As mentioned above, it is imperative that both the surgeon and the anesthesiologist understand the importance to patient safety of adequate and sustained relaxation during the computer-assisted robotic portion of the procedure. This is a paramount concern for the following reasons: (1) the daVinci® system (Intuitive Surgical Inc., Sunnyvale, CA) employs several fixed trocars, so patient movement can result in serious trauma to major vascular and visceral structures; (2) disruption of the magnified surgical field and/or surgical activity with even the smallest patient movements can prove disastrous; and (3) preservation of delicate pelvic structures such as the autonomic plexus surrounding the prostate cannot be reliably achieved in a moving patient.[21] The anesthesiologist should consider the use of an infusion of muscle relaxant during robotic surgery, particularly if access to the patient for train-of-four monitoring is limited.

Although many drugs are suitable in this context, atracurium and cisatracurium have a substantial advantage. They both have predictable chemical breakdown by Hoffmann elimination (which does not rely on either intact hepatic or renal function), so their action will be reliably terminated after a reasonably short interval.[22] This remains true even in the face of inadvertent overdosage. It should be considered acceptable for a small number of patients to remain intubated and sedated for a short while in the recovery area. Intensive care unit (ICU) admission is rarely indicated because of paralysis if these drugs are utilized. Good communication concerning patient relaxation between surgical and anesthetic personnel is crucial, given the gravity of the potential complications should relaxation prove inadequate.

The following is an example of appropriate infusions for a hypothetical 70-kg male patient. Cisatracurium doses of 0.15 to 0.20 mg/kg ($3 \times ED_{95}$–$4 \times ED_{95}$) yield excellent relaxation for intubation in 90 to 120 s.[22] During induction, a 70-kg male would receive 10.5 mg to 14.0 mg of cisatracurium. Recovery from this initial bolus will be expected between 20 and 30 min. It is recommended that an infusion of 1.0 to 2.0 mcg/kg/min (70–140 mcg/min in our 70-kg male) be initiated within 10 min of this initial bolus to maintain adequate relaxation if train-of-four can be monitored. Cisatracurium is reliably and completely eliminated by Hoffman elimination in all patients so there is no reason to wait for recovery from the initial dosing before beginning the infusion. If the clinician cannot functionally and reliably monitor train-of-four in the patient secondary to insufficient access, a higher infusion of 2.5 to 3.0 mcg/kg/min is recommended for maintenance of relaxation until the robotic portion of the procedure is completed. A suitable regimen can also be devised utilizing atracurium, which shares many of the same properties of cisatracurium. Atracurium generally has a faster onset of action and termination of action compared to cisatracurium, and is also associated with greater histamine release (see Figure 9.3).

Positioning during computer-assisted robotic urologic surgery is crucial for patient safety. To protect the patient from the robotic device requires planning and knowledge of the procedure to be completed. Sometimes the robot is positioned to the side of the patient, limiting access to the head and airway, and other procedure require it to be place at the foot of the bed reaching over the patient.[23] Either way, the key point is that once the robot is positioned and engaged, little can be done to change a patient's position.


**FIGURE 9.3.** Cisatracurium infusion.

## 9.4. Recovery/Pain Control Issues

Minimally invasive surgery has many benefits in the area of postoperative pain control and recovery. It has been clearly shown that patients receiving procedures of this type have shorter hospitalizations and lower overall pain levels than with equivalent open procedures.[24] Available modalities for pain control include intravenous opioids, intramuscular opioids, oral opioids, adjunctive nonopioid analgesic medications, and catheter-delivered local anesthetics (see Figure 9.4).

**FIGURE 9.4.** Placement of On-Q® Pain Pump (I-Flow Corp., Lake Forest, CA) for infusion of local anesthetics postoperatively.

No single opioid is superior and any modality of treatment must be selected based upon the individual patient's specific requirements and sensitivities to medications. As demonstrated by the small size of the incisions in Figure 9.4, a small proportion of the pain involved in these procedures is somatic in origin. Most pain in the first 24h is visceral in origin, and is well controlled by opioids and other pharmacologic interventions. Regional (neuraxial) modalities, with their attendant risk of complications, may also be utilized in those rare patients with high opioid tolerances, but are unnecessary for most patients.

## 9.5. Conclusion

This chapter has provided both surgeons and anesthesiologists with a quick reference, guiding optimal peri-operative care in patients receiving robotic urologic surgery. Information critical to ensuring patient safety when utilizing computer-assisted surgical techniques has been discussed. The patient population has been explored and laproscopic considerations have been reviewed. Extensive discussion concerning specific robotic issues and patient positioning were touched upon. Minimally invasive surgery generally offers superior recovery with much reduced pain. The advancement of surgery into the digital and computer-assisted era creates new anesthetic challenges, for which a useful road map has been provided.

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