Robotics in practice: New angles on safer positioning

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Robot-assisted laparoscopic surgery is becoming more prevalent and typically is performed in the steepest degree of Trendelenburg possible, yet such positioning can cause several perioperative complications and may, in fact, be unnecessary for benign gynecologic procedures.

Application of the da Vinci Surgical System (Intuitive Surgical Inc, Sunnyvale, California) in gynecologic surgery has been exponentially increasing since it was approved by the United States Food and Drug Administration for that indication in 2005. Robot-assisted laparoscopic surgery, widely referred to as da Vinci surgery, was introduced to overcome many of the shortcomings of conventional laparoscopy and now is in use at many centers across the United States for gynecologic, urogynecologic, and gynecologic oncology procedures. The advantages of robot-assisted laparoscopic surgery over conventional laparoscopy are 3-dimensional camera vision, superior precision and dexterity (EndoWrist instrumentation), elimination of operator tremor, and less fatigue on the part of the surgeon. The drawbacks of the technology include high cost, bulkiness, and lack of tactile feedback.

Proper patient positioning on the operating table is essential to allow optimal surgical exposure and to prevent neuromuscular injuries. Positioning is even more critical in robotic surgery because it must provide access to the surgical field and also accommodate the robotic camera system and working arms. As a result, a steep Trendelenburg position (roughly defined as 30° to 40°) is routine during robotic gynecologic surgery, much more so than during conventional laparoscopy. Part of the reason is that once the robot is docked with arms engaged to the instruments, adjusting the table is not feasible without undocking the robot. That has led to a tendency to use the steepest degree of Trendelenburg possible to maximize surgical exposure and avoid having to readjust the table if more Trendelenburg is required. Performing robotic gynecologic surgery in steep Trendelenburg, however, is associated with rare but serious perioperative complications and the robotic surgical team must have an in-depth understanding of the potential complications that may arise when patients are positioned in this way. [1]

This article discusses strategies to simplify patient positioning for robot-assisted gynecologic surgery without compromising patient safety or surgical outcome. It also reviews frequently reported complications of robotic surgery attributed to patient positioning and offers recommendations for preventing such adverse events.

FIGURE 1: The patient's extremities are well-padded and stabilized using foams and sleds, and her eyes are covered with protective gear.

PATIENT POSITIONING FOR ROBOT-ASSISTED SURGERY

Positioning of a patient for robot-assisted surgery starts with placement in the dorsal lithotomy position with the legs in Allen Yellofins stirrups (Allen Medical Systems, Acton, Massachusetts), as with conventional laparoscopy (Figure 1). The same principles for adequate padding at all pressure

points and avoidance of extreme flexion, extension, and abduction should be followed to help minimize neuromuscular injuries. Padding of the occiput (such as with a gel donut, as shown in Figure 2) cannot be overemphasized to avoid ischemic necrosis resulting in alopecia. A standard motorized operating-room table featuring a maximum 30° tilt is used.

Several steps are recommended to prevent a patient in steep Trendelenburg from shifting while on the operating table. The first is to place a 3' x 5' surgical sheet horizontally in the middle of the table, corresponding to the position of the patient's arms, put a layer of egg-crate foam on top of it, and securely tape the foam to the surgical bed (Figure 2). (The sheet can be used later for tucking.) A tip suggested by other authors is to use 2 layers of egg-crate foam as "anti-skid" material to prevent sliding, which may be particularly helpful for patients who are morbidly obese. [2] Placing surgical gel pads against a patient's bare skin also may be helpful, but they have to be disinfected after each case and allergic reactions are possible. Some surgeons have success in protecting and stabilizing the arms of obese patients with well-padded arm sleds (Figure 1) made of rigid plastic material, which are designed to cradle the arm and extend under the mattress.

Another device designed to stabilize positioning and provide sufficient padding for robot-assisted surgery in steep Trendelenburg is the Bean Bag Positioner (AliMed Inc, Dedham, Massachusetts). The gel mattress is fastened to the surgical table and conforms to the shape of a patient's upper body and shoulders when desufflated to stabilize her. Potential drawbacks are a longer setup time, unnoticed deflation during the case, and need for disinfection.

FIGURE 2: The author's preferred method of padding for robot-assisted surgery, with a layer of egg-crate foam taped to the table mattress and a folded sheet to be used for securing the patient's arms.

Our preferred method for patient positioning in robot-assisted gynecologic surgery is to use 1 layer of egg-crate foam and tuck the patient's arms using sheets or arm sleds. In our experience, this is the most straightforward, consistent, and quick way of setting up the operating room table for patient stabilization. As described later in this article, we rarely, if ever, feel the need for steep Trendelenburg, even for morbidly obese patients. If prolonged steep Trendelenburg (30° to 40° of table tilt) is anticipated, however, a surgeon can consider using one of the strategies previously described to prevent the patient's position from shifting.

PHYSIOLOGIC EFFECTS OF PNEUMOPERITONEUM IN STEEP TRENDELENBURG

The robotic surgeon and anesthesia team must understand the physiologic effects to the patient of pneumoperitoneum in the steep Trendelenburg position. Pulmonary functional residual capacity is impaired during robotic surgery because of insufflation and the Trendelenburg position.[3] Hypercapnia and acidosis can ensue secondary to a ventilation-perfusion mismatch. Increasing minute volume may correct this abnormality, but patients with pulmonary compromise may not tolerate such physiologic strains during robotic surgery in steep Trendelenburg.

Cardiovascular effects of robotic surgery in steep Trendelenburg also can be problematic. Venous return and cardiac preload are reduced secondary to pneumoperitoneum. Patients also have an increase in cardiac afterload secondary to compression of the aorta and increased vascular sympathetic tone. The result can be a reduction of cardiac index by as much as 50% and elevation of pulmonary arterial, central venous, and intracranial pressures. Cardiac arrhythmias may occur in as many as 27% of patients, mostly secondary to increased vagal tone and hypercapnia.[4]

To reduce and successfully manage challenges related to anesthesia and patient positioning during robotic surgery, the robotic surgeon should collaborate closely with a dedicated anesthesia team that is knowledgeable about specific physiologic issues related to performing robotic surgery in steep Trendelenburg.

POTENTIAL COMPLICATIONS OF STEEP TRENDELENBURG

Steep Trendelenburg traditionally is recommended for robotic gynecologic surgery to maximize surgical exposure of the pelvis. Although there is no clear definition of steep Trendelenburg, 30° to 45° of table tilt is considered a steep angle. Several perioperative complications can arise from performing robotic surgery in such a position, especially if surgery is prolonged.[1]

Patient slippage

The most obvious concern is cephalad sliding or slippage of the patient on the operating table. That is a particular concern in obese patients, who are more susceptible to downward shifting, with resulting skin breakdown and neuropathic injuries. Nerve injuries can result from overstretching or compression of the nerve bundles, leading to impairment of the microcirculation and nerve conduction.[2] These injuries are an important source of perioperative morbidity and can be either transient or permanent. Some previously proposed methods to prevent patient slippage in steep Trendelenburg are now known to contribute to nerve injury. As a result, we do not recommend the use of shoulder straps, shoulder braces, restraints, body straps, or head rests during robotic surgery because of associated neuromuscular injuries, particularly brachial plexus injury.

Patient slippage during the use of fixed robotic trocars also can cause incisional tear, postoperative hernia formation, and increased postoperative pain secondary to overstretching of the anterior abdominal wall. Accurate patient positioning, careful padding of all pressure points, and appropriate application of antiskid materials therefore are paramount for preventing such injuries.

Rhabdomyolysis

Another devastating complication after robotic surgery related to patient positioning is the development of postoperative rhabdomyolysis.[5] Rhabdomyolysis after bariatric surgery is well documented. Morbid obesity, prolonged surgery, extreme patient positions (such as steep Trendelenburg), hypertension, diabetes, and peripheral vascular disease all are risk factors for this complication. Rhabdomyolysis results from compression injury of the skeletal muscle, causing intracellular components (myoglobin, electrolytes, and proteins) to be expelled into the circulation. That, in turn, can result in serious complications, including acute renal failure, hyperkalemia, arrhythmia, compartment syndrome, metabolic acidosis, and significant pain. A patient's gluteal, back, and shoulder muscle groups are at particular risk in steep Trendelenburg during robotic surgery. Intractable postoperative pain in these areas should serve as a warning sign. The diagnosis is confirmed if the total serum creatinine kinase level is higher than 1000 IU/L or if myoglobinuria is present.[5,6] Management includes aggressive fluid resuscitation and correction of metabolic acidosis. If precautions are taken, the risk of rhabdomyolysis after robotic surgery should be similar to that after laparoscopic and open surgery. Gynecologists adopting robotic technologies should be familiar with the pathophysiology, diagnosis, and management of this complication.

Facial trauma and corneal abrasion

A patient's face and especially her eyes are at risk of direct injury during robotic surgery, in contrast to conventional laparoscopy, and they should be given particular consideration during positioning and throughout the procedure. During robotic surgery, especially when the ports are placed superior to the umbilicus, the robotic camera system may come in contact with a patient's face, causing facial and ocular trauma such as corneal abrasions. That is particularly problematic when a 30° down scope is used in steep Trendelenburg because the camera system may be only a few centimeters away from the face. There are no standard recommendations for the best way to protect a patient's face and eyes during robotic surgery. Face masks, Mayo stands, foam wraps, and adhesive eye shields (Figure 1) all have been used, but no one method has proven superior to the others.

We have noticed a few cases of corneal abrasion after robotic surgery at our institution despite taking preventive measures. Corneal abrasion is the most common ocular complication after any surgical procedure.[7] Most abrasions are thought to be caused by lagophthalmos (failure of the eyelid to fully close), which results in corneal drying. In addition, general anesthesia reduces tear production and, therefore, increases the incidence of this painful condition. Direct trauma causes up to 20% of perioperative corneal abrasions. The cornea is very sensitive to oxygen deprivation. For example, an ill-fitted mask or tightly applied facial foam wrap that applies pressure to the eye globe will induce corneal hypoxia and dryness. Desquamation of the epithelial layer more readily induces abrasion in a hypoxic and dry environment. Corneal abrasion can also result from increased intraocular pressure and edema, as occurs in steep Trendelenburg.[7]

To protect against corneal abrasion, we recommend taping the patient's eyelids shut after induction of general anesthesia. Aqueous solutions, viscous gels, and ointments also are used routinely, but some experts recommend against such measures because of insufficient added protection and possibly increased ocular morbidity, especially with ointments. Our hospital's policy is application of the disposable IGuard eye protector (Figure 1, SunMed, Largo, Florida) once a patient's eyes are taped shut and avoidance of lubricating eye ointments.

Intraocular pressure rises significantly in steep Trendelenburg.[8] As early as the 1950s, serious ocular complications, such as retinal detachment, were attributed to this positioning.[9] Two patients developed ischemic optic neuropathy leading to partial visual loss and complete blindness after prolonged robotic surgery in steep Trendelenburg.[10] As more gynecologic procedures are performed with robots, more ocular complications attributed to increased intraocular pressure and ischemic optic neuropathy may be encountered, especially in elderly patients who may have elevated baseline intraocular pressure.

Facial and laryngeal edema

Most patients undergoing prolonged robotic surgery in steep Trendelenburg awake from anesthesia with varying degrees of facial and laryngeal edema.[1] Consequently, postextubation respiratory distress can occur, with the need for reintubation.[11] Several measures may help prevent this complication, such as selecting patients carefully, avoiding prolonged operative time, reducing the degree of Trendelenburg, and decreasing intraoperative volume replacement.

DEGREE OF TRENDELENBURG: PILOT STUDY

To reduce the potential complications of robotic surgery attributed to patient positioning, we recently completed a pilot study to investigate the safety and effectiveness of performing robotic

gynecologic surgery without routine use of steep Trendelenburg.[1] We demonstrated that routine patient positioning in steep Trendelenburg for benign robotic gynecologic surgery seems to be unnecessary. Twenty consecutive robotic gynecologic procedures for benign indications were included in the study (Table 1). Patients were positioned to obtain sufficient surgical exposure, as opposed to being routinely placed in the steepest degree of Trendelenburg possible. The degree of Trendelenburg was measured using a digital level after each case was completed. The surgeons were blinded to the degree of Trendelenburg used until after the study was completed.

Our mean degree of Trendelenburg was 16°, which is far less than the recommended 30° to 40°.[1] All cases were completed successfully without a need to modify the table tilt. There were no perioperative complications, and the operating times were similar to those in previous reports. We, therefore, advise that patients undergoing robotic gynecologic surgery for benign indications be placed in as much Trendelenburg as is safely needed to provide sufficient bowel mobilization and exposure, rather than routinely using the steepest degree of Trendelenburg possible. Avoiding routine use of steep Trendelenburg in robotic surgery would potentially reduce, if not eliminate, issues pertaining to position slippage and related perioperative complications. The likelihood of intraoperative and anesthesia-related complications also would be decreased because less physiologic strain is placed on a patient's body.

Abbreviations: BMI, body mass index; BSO, bilateral salpingo-oophorectomy; CI, confidence interval; EB L, estimated blood loss; LSH, laparoscopic supracervical hysterectomy; NA, not applicable; R, robot-assisted; TLH, total laparoscopic hysterectomy; SD, standard deviation.

SUMMARY

Steep Trendelenburg positioning during robotic gynecologic surgery is associated with potentially serious perioperative morbidity. The robotic surgeon and the anesthesia team must be intimately familiar with these complications and take preventive measures to reduce the risk to patients. Routine adherence to the steepest degree of Trendelenburg achievable in robotic gynecologic surgery for benign indications should be questioned. Robotic gynecologic surgery without steep Trendelenburg appears to be feasible without compromising surgical outcomes and arguably will reduce several complications attributed to this position.

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