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Review Article

Anesthesia for Trans-Oral Robotic Surgery: Practical Considerations

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Abstract

Ever since the advent of robotic surgery, its applications have ramified into almost every part of the human body. Trans-oral robotic surgery is a recent addition to this ever-increasing field of minimally invasive surgery. The daVinci ™ robotic system is utilized to access difficult to reach areas of the oral cavity. Improvements in surgical technology also pose various patient safety concerns and newer challenges for the anesthesiologists. The important anesthetic considerations include proper positioning of anesthesia work station, operation table and the robot; meticulous difficult airway management both during intubation and extubation; control of sympathetic stimulation following intra-oral introduction of robotic instruments; judicious fluid therapy; postoperative tracheal tube retention and adequate postoperative pain management. This review article aims to address these concerns and challenges in a concise manner for the entire robotic surgery team in general and anesthesiologist in particular.

Keywords: *Transoral Robotic surgery; Anesthesia; Difficult airway; Robotic arms; Sympathetic stimulation; Patient safety*

Introduction

Trans-oral robotic surgery (TORS) is a minimally-invasive approach to deep-seated tumors of the oral cavity. It uses the da-Vinci ™ robotic surgical system (Intuitive Surgical, Sunnyvale, California, USA)[1] for radical surgery of head and neck cancers. Its purported advantages include less blood loss, better cosmesis, and improved view of difficult-to-reach lesions, minimal pain and early postoperative recovery [2]. Its indications have been extended to radical tonsillectomy [3], partial laryngectomy, glossectomy and other complex intra-oral lesion excision. A dedicated surgical safety check-list [4] must be utilized for robotic surgeries. The wristed robotic arms are advantageous in improving dexterity [5] and filtering of hand tremors of the operating surgeon. Surgical precision can be obtained by optimal port placement with non-collision of the robotic arms. This, in conjunction with a 3D camera can confer a 15-fold magnification of the surgical field and allows for better preservation of critical anatomical structures. All the instruments have seven degrees of freedom with "endo-wrist" technology. Drawbacks of robotic surgery [6] relate to issues of cost, lack of tactile feedback and over-reliance on the patient side surgeon. Widespread adoption by more high-volume centers across the globe will help mitigate the costs.

Introduction of the fourth robotic arm can provide more freedom to the robotic console surgeon. Nasotracheal intubation is usually done for securing the airway to give enough room for the surgeon to accommodate and work with his robotic instruments. Flexomettalic tube is selected for intubation so as to prevent tube kinking or occlusion by the robotic arms and mouth gag in TORS. Anesthesiologists along with the entire robotic surgery program staff must ensure that all aspects of patient safety must be taken care-off. Team work and eternal vigilance is the key to success.

Arrangement of the robotic system for TORS

Trans-oral robotic surgery is unique among robotic surgeries as the area of interest is shared between the surgeon and the anesthesiologist. Positioning of the patient, anesthesia work station and the robot must be such that there are no bottlenecks in their individual functioning. Spatial restrictions due to the bulky equipments have to be kept in mind for TORS, as for other robotic surgeries. As the

surgical cart is positioned near the patient, he/she should be protected against inadvertent contact due to motions of the robotic arms. The operating table may need to be turned such that the robotic arms come over the head-end, the vision tower is positioned on one side of the patient and the anesthesia machine is on the foot-end of the table. This means that the breathing circuit needs to be longer and consideration must be given for the resultant increase in dead space (by adjusting the ventilatory parameters).

The detection of ETCO2 (end-tidal carbon dioxide) may also be delayed through a conventional carbon-dioxide analyzer. This is of special importance in detection of intra-operative air embolism or circuit disconnections. Extension lines must be applied to intravenous catheters as the patients' hands may be positioned away from the anesthesiologist. Utmost care should be taken to prevent air from entering these long lines. The robotic console for the main surgeon can be positioned at a comfortable distance from the patient in a suitable corner of the O.R. It must be remembered that after docking of the robot, access to the patient is limited and any change in patient position is not possible. The entire robotic surgery team must be well-versed in quick de-docking [7] of the robot in emergency situations. Conducting separate mock drills and simulation-based learning for emergency de-docking of the robot can be beneficial in this regard. All lines (intravenous and invasive), monitors and patient-protective appliances need to be secured before-hand to prevent kinking or displacement. Patient positioning, especially of the head and neck must be gentle for TORS. Neck extension, which is applied for insertion of robotic instruments, may need to be limited in patients with cervical spine deformities. Application of shoulder supports, braces and bandages to the patient should be done cautiously in order to avoid pressure on vulnerable areas. Sequential compression stocking devices (SCD) [8] must be applied to the legs during the procedure.

Early postoperative mobilization must be encouraged where possible, to reduce the risk of deep vein thrombosis. Since access to patient and airway is limited, anesthesiologists must check and secure all circuit connections, monitors and vascular lines, both before and after docking and de-docking of the robot.

Management of airway for TORS

Airway management for TORS can be challenging in view of the nature or extent of the cancerous growth and the possibility of airway obstruction. Standard ASA (American Society of Anesthesiologists) guidelines for difficult airway (DA) [9] management must be meticulously followed. All preparations for DA management must be ensured preoperatively, including availability of fibreoptic bronchoscope, videolaryngoscope, cricothyroidotomy and tracheostomy sets. Adequate nasal preparations [10] (xylometazoline drops followed by packing with ribbon gauze soaked in 4% lignocaine) must be carried out and the more patent nostril should be selected for nasotracheal intubation, after preoxygenation. An armoured (flexometallic) endotracheal tube prevents kinking of the tube due pressure from robotic arms or patient side surgeon. The C-MAC TM videolaryngoscope [11] serves as an excellent tool for securing the airway in these situations, as the cancerous lesion can also be visualized well.

Spontaneous respiration should preferably be maintained till the insertion of a definitive airway and muscle relaxant must be given only after confirming correct tube placement. Awake FOB-guided nasal intubation [12] can be employed in patients with limited mouth opening and trismus. This requires local anesthetic airway blocks [13] (superior laryngeal nerve block, trans-tracheal block and glossopharyngeal nerve block) as well as good patient cooperation. "Say-Go" (spray-as-you-go) technique [14] can also be utilized during insertion of fibre-optic bronchoscope for anesthetizing the airway. In certain situations, posterior pharyngeal wall lesions may necessitate insertion of orotracheal tube, which may prove challenging as the tumor can obstruct the entry of the tube. Some patients undergoing TORS may need a preoperative tracheostomy, whose patency needs to be checked before anesthesia induction. In contrast to open radical surgeries, the nasogastric tube (for gastric decompression and postoperative nutrition) must be inserted only after complete excision of the tumor mass and frozen section clearance of the margins. In this regard, the authors opine that the C-MAC TM videolaryngoscope is of particular benefit in assisting difficult Ryle's tube insertion and in visualizing any residual tumor growths.

Hemodynamic Stabilization and Monitoring during TORS

In TORS, airway handling occurs not only during laryngoscopy and intubation, but also during assembly of the robot and during the actual surgical process. Drugs [15] like fentanyl, lignocaine, esmolol or clonidine may be intravenously administered just before induction to blunt the resultant hemodynamic response.

Muscle relaxant infusion under neuromuscular monitoring (maintaining 6-8 post-tetatic counts) is required to maintain adequate surgical relaxation and prevent even slight patient movement during robotic surgery [16]. The major cardiovascular changes associated with insertion of the mouth gag and robotic arms include tachycardia, hypertension and increase in systemic vascular resistance. Deepening the plane of anesthesia during oral introduction and setting of robotic instruments can be done by raising the infusion rate of intravenous Propofol or increasing the inhalational anesthetic agent. Maintenance of anesthesia with Desflurane [17] is usually preferred for TORS as it ensures early recovery from anesthesia (blood-gas co-efficient 0.424 and MAC 7.3%). Intra-operative hemodynamic stability can be maintained with one or more of the following agents: esmolol [18] boluses or infusion (0.5-1 mg/Kg bolus or 50-100 mcg/Kg/Min infusion); NTG [19] (nitroglycerin) infusion (5-10 mcg/min infusion); labetolol [20] bolus (5 -20 mg) or infusion (1-2 mg/min infusion); intermittent opioid boluses (20-30 mcg Fentanyl or 8-25 mcg/Kg Sufentanil); and continuous Remifentanil infusion [21] (0.25-0.5-1 mcg/Kg/min). Esmolol hydrochloride is an ultra-short acting beta-blocker. NTG is a direct acting vasodilator. Labetolol is a combined alpha and beta blocker. Remifentanil is a unique, ultra-short acting opioid with a rapid onset (1.3 minutes) and offset of action (context sensitive half time = 3 - 5 minutes), with fast and predictable titration of effect and unaltered pharmacokinetics in patients with obesity, renal or hepatic dysfunction.

Laryngeal reflexes can be stimulated by the handling of the areas in-and-around the deep-seated cancerous growth. The main concern is the rise in sympathetic stimulation following application of mouth gag to open the mouth for accommodating robotic instruments [22]. This can disturb the delicate balance between myocardial oxygen demand and supply, leading to triggering of myocardial ischemia. Uncontrolled hypertension can also lead to bleeding, cerebro-vascular and renal complications. Special care should be taken during this stage in patients with co-existing cardiovascular diseases. There have been isolated case reports of the successful outcome of TORS in cardiomyopathy [23] patients.

Postoperative Care

Postoperatively, the patients are usually reversed, but not extubated, in anticipation of airway edema following intra-oral surgery. Flexomettalic tube may be changed to portex (PVC) cuffed endotracheal tube (ETT) with the help of a tube exchanger device before reversing neuromuscular blockade. All patients must preferably be monitored in a dedicated onco-surgical intensive care unit with the nasotracheal tube in-situ. All patients must be explained in the preoperative visit about the possibility of postoperative retention of the tube. Humidified oxygen can be administered through a T-piece set connected to the distal end of the retained ETT.

They can be extubated after 24 to 48 hours over an airway exchange catheter, with supplemental esmolol boluses in-order to prevent sympathetic stimulation. Remifentanil infusion can also be utilized (where available) as it facilitates clear-headed recovery, rapid extubation and effective post-operative pain management [24]. Tube exchanger device [25] must be utilized in view of pre-existing difficult airway. In addition to the above airway precautions, the patient must be kept adequately warm. Monitoring must continue in the postoperative period to detect any untoward events. Pre-existing co-morbidities, like hypertension, diabetes, coronary artery disease or thyroid disorders must be also be managed appropriately. Patients with reactive airway disease may pose special problems, like bronchospasm during both intubation and extubation. Perioperative steroid and beta-2 agonist nebulization and aerosol inhaler can be administered through the endotracheal tube for immediate relief in these patients. Beta-blockers are generally avoided in this subgroup of patients and opioids in adequate doses must be given early in surgery to control the heart rate. Elderly patients and those with concurrent cardiac illnesses are prone to develop arrhythmias in the postoperative peri-extubation period, which needs to be detected and treated promptly. In all patients, both DVT [27] (deep vein thrombosis) and PONV (postoperative nausea vomiting) prophylaxis must be given.

Pain Management

Postoperative analgesia is usually multi-modal, with intravenous paracetamol, NSAID`s (non-steroidal anti-inflammatory agents) and Fentanyl infusion (30-40 mcg/hour) for the first 12 to 24 hours. Alternatively, IVPCA (intravenous patient controlled analgesia) with opioids (Fentanyl or Sufentanil) can be utilized for better patient comfort. Ultrasound-guided mental block and superficial cervical plexus block [27] can be supplemented in patients with extensive neck dissections. In patients taking oral morphine preoperatively for cancer pain, their total 24-hour dosage should be calculated and supplemented by equivalent (oral morphine dose is roughly three times the intravenous dose) intravenous morphine postoperatively [28].

Conclusions

TORS is a promising, minimally invasive head and neck robotic surgery, with the ability to work around corners, while avoiding certain line-of-sight limitations. The prime perioperative concerns include proper positioning of the anaesthesia workstation, breathing circuit modification, control of sympathetic stimulation following insertion of mouth gag or robotic arms, judicious fluid therapy, cautious positioning, padding of eyes, postoperative tube retention, and meticulous difficult airway management. Anesthesiologists must be prepared to face the challenges posed by improvements in surgical technology, especially in high risk patient population.

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