Robotic Surgery/Sleep Apnea in Children

Anesthesia for Robotic Surgery

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Development of robots: definition — term coined in 1921; mechanical device, sometimes resembling humans, capable of performing variety of complex human tasks on command or with programming (automatically or via remote control); adapted by military for use in medicine in 1980s, with goal of remotely providing good surgical care for battlefield injuries; however, latency associated with long geographic distances renders such procedures infeasible for humans; actions of surgeon “teleported” to patient; robot enhances precision, but not capable of independent action

Advantages of robotic assistance: laparoscopy introduced in mid 1980s; robotically assisted laparoscopic procedures improve visibility of operative field (3-dimensional imaging systems provide binocular vision through console, while unassisted laparoscopy uses 2-dimensional monitors); computer modification improves control of fine movements and reduces fulcrum effects; 7 degrees of freedom, with added “wrist” movement of robot, superior to 5 degrees of freedom with traditional instruments

Procedures performed with robotic assistance: cardiac — eg, mitral valve reconstruction, total endoscopic coronary artery bypass (TECAB), intracardiac tumor resection, epicardial lead implantation, ablation for atrial fibrillation; stated benefits include avoidance of sternotomy (also possible without robot), very small incision, less surgical trauma, possibly better visualization, greater range of motion, long-shafted minimally invasive instruments, and reduced bleeding (questionable); thoracic surgery — eg, resection of solid tumors, particularly those located in apex, resection of esophageal tumors (eg, leiomyoma), thyroidectomy (incision made in axilla, then “tunneled” to thyroid; leaves no scar on neck but may cause injury to axillary nerve); orthopedic surgery — ROBODOC (available for many years) holds things steady; otolaryngology head and neck surgery (OHNS) — used for transoral resection of benign and malignant lesions of pharynx and larynx, and cancer resections of supraglottis, tonsil, and tongue base; crowded surgical field and positioning of patient 90° to 180° away from anesthetist makes intervention difficult if problems develop with airway; pediatric surgery — multiple procedures proposed for children and infants, with major limitation size of robot relative to size of patient (may require awkward positioning of patient); neurosurgery — robot offers steadier maneuvers; general surgery — considered useful only for procedures based within one quadrant of abdomen; advantages include fine dissection, microsuturing, and reconstruction; used for cholecystectomy, with no findings of improved outcomes or safety; gynecology — used for malignant disease, myomectomy, tubal resection, and pelvic reconstructive surgery; urology — eg, radical prostatectomy with lymph node dissection, cystectomy, pyeloplasty; summary — most beneficial for complex reconstructive processes; ambulatory surgery — at present, robot has no role for procedures done in this setting

Anesthesia for robotic surgery: preoperative considerations — patients with significant cardiovascular or respiratory disease should consider alternative approach; glaucoma or central nervous system pathology may be exacerbated due to increased intraocular pressure or cerebral blood volume associated with required positioning

Techniques: general endotracheal anesthesia (GETA) indicated (muscle relaxation required and mechanical ventilation necessary for thorascopic and laparoscopic procedures); routine monitors adequate for most patients; arterial line vs central venous access chosen on basis of patient’s comorbidities; 2 large-bore intravenous (IV) lines necessary (access to patient limited); thermal blanket used to maintain body temperature; orogastric tube (OGT) indicated for most cases; sequential compression stockings recommended

Intraoperative concerns: positioning — often extreme head-down; duration of procedure — often ≥60 min required for preparation and positioning before incision; other — hypothermia (avoided via use of thermal blanket and fluid warmer); hemodynamic and ventilatory effects of pneumoperitoneum; occult blood loss; patients must be kept in stable position with muscle relaxation to avoid potential tearing of port sites; relaxation should be monitored and maintained at ≤2 twitches; robot fixed (does not move if patient coughs or moves)

Positioning: pelvic surgery requires lihotomy and deep Trendelenburg position; upper abdomen and diaphragmatic surgery allow supine position, but steep reverse Trendelenburg also used; chest — lateral, with variations of Trendelenburg positions; mediastinal procedures generally require lateral position with lateral tilt; other issues — airway often 90° to 180° away, and access difficult (eg, verifying tube position during one-lung ventilation); logistics difficult in room crowded with equipment, wires, and cables; route of access should be planned, and positioning verified from beginning (repositioning difficult); placement of robotic arms important for preventing patient contact and pressure or crush injuries; caution required with placement of light sources (to prevent fire or thermal injury); shoulder blocks must be properly positioned to avoid brachial plexus injury; lumbotomy position — peroneal nerve injury

Educational Objectives

The goals of this program are to improve the management of patients undergoing robotic surgery and pediatric patients with obstructive sleep apnea (OSA). After hearing and assimilating this program, the clinician will be better able to:

1. Identify appropriate applications of robotic surgery in different surgical specialties.
2. Position patients properly to prevent injury during robotic surgery.
3. Prevent complications specific to robotic surgery.
4. Recognize the signs and symptoms of OSA in pediatric patients.
5. Use appropriate adjuvant therapies for management of postoperative pain in pediatric patients who have undergone tonsillectomy and adenoidectomy.

Faculty Disclosure

In adherence to ACCME Standards of Commercial Support, Audio-Digest requires all faculty and members of the planning committee to disclose relevant financial relationships within the past 12 months that might create any personal conflicts of interest. Any identified conflicts were resolved to ensure that this educational activity promotes quality in health care and not a proprietary business or commercial interest. For this program, the faculty and planning committee reported nothing to disclose.
possible; speaker keeps patients’ arms tucked and uses beanbag with adhesive tape across chest; Trendelenburg position tested before draping

Pathophysiology: similar to nonrobotic laparoscopic and thoracoscopic procedures; positioning and CO₂ insufflation may cause difficulty with ventilation and oxygenation (surgeon may need to lower insufflation pressure); consideration of pressure-control ventilation and monitoring of peak inspiratory pressure recommended; elevated filling pressures documented but diastolic function preserved and cardiac output unaffected in patients with American Society of Anesthesiologists (ASA) physical status 1 or 2; caution advised before proceeding in patients with pulmonary or cardiovascular disease; fluid management—fluids should be minimized to avoid dependent edema; postextubation respiratory distress possible; however, fluids necessary for pyloplasty

Clinical pearls: check placement of endotracheal tube frequently and avoid tube migration; check face regularly, use orogastric tube, and administer ranitidine to avoid oral ulceration and conjunctival burns due to reflux of gastric contents; placement of oximeter probe on ear may cause erroneous readings; maintain normocarbia; establish and practice protocols for emergency removal of robot

Emergence from anesthesia: reverse neurumuscular blockade; cerebral edema may cause delayed emergence; provide multimodal analgesia; caveat—applicability of robotic procedures for obese patients questioned

Complications: result from limited access to patient, inexperience of surgical team, and occult blood loss (no different from those in nonrobotic procedures); literature limited to observational studies and surgeons proficient with robot (biased toward success); comparisons of outcomes show no advantage to robotic procedures; long operating times contribute to peripheral nerve injury, compartment syndrome, rhabdomyolysis, ventilatory difficulties, and cerebral edema

“Buyer beware”: cost of robotic console (≥$1.3 million); disposables and service contract add to investment; institutions feel pressure to obtain robots to remain competitive

Anesthesia by robot: robot (McSleepy) provided anesthesia during surgery using da Vinci (2010); increase in time for robotic intubation similar to that for transition from laparoscopic to robotic surgery (ie, time doubled); da Vinci system able to perform regional anesthesia (holds probe and needle)

Sleep Apnea in Pediatric Patients

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Practice guidelines: several reports of adults with obstructive sleep apnea (OSA) who underwent general anesthesia and died after discharge home prompted ASA to create practice guidelines for OSA, with brief mention of pediatric patients; no clinical predictors available for children (body habitus and activity level not reliable)

Clinical presentation: 1% to 3% of children diagnosed with OSA; often encountered when presenting for tonsillectomy and adenoidectomy; revised indications for tonsillectomy and adenoidectomy reveal >75% performed for OSA, whereas infectious etiologies predominated in 1970s; overall number of procedures increasing (possibly related to better recognition of OSA)

Complications of OSA: similar to those in adults; include increased systemic and pulmonary vasculature, hypertension, and remodeling of left ventricle; elevated pulmonary artery pressure leads to pulmonary hypertension (ultimately, cor pulmonale); pediatric-specific complications include growth impairment (resolves with treatment) and central nervous system changes (eg, neurocognitive defects, learning deficiencies, behavioral problems [most commonly, attention-deficit/hyperactivity disorder, increased impulsivity, and aggressive behavior; improvement noted with treatment of OSA])

Diagnosis: disorder of breathing during sleep, characterized by partial upper airway obstruction and/or intermittent complete airway obstruction that disrupts normal ventilation during sleep and normal sleep patterns; occurs exclusively during rapid eye movement (REM) sleep in children

Signs and symptoms: snoring—sensitive but not specific; ≤25% of children experience snoring with no evidence of OSA; gapping, snoring, and observed apneic events—more diagnostic, but not always discernible by parents; daytime hyperactivity—in children, more common than sleepiness; other combination of snoring and bedwetting strong indicator of OSA

Pathophysiology: 2 distinct forms; 1) peak in young children results from enlarged tonsils (this type receives most benefit from tonsillectomy and adenoidectomy); 2) presents much as in adults (with, eg, obesity, short thick neck, metabolic sequelae) and does not respond well to tonsillectomy and adenoidectomy alone

Screening tests: full sleep study gold standard and only recognized test for children; performance by pediatric sleep specialist and use of pediatric scoring recommended; apnea-hypopnea index (AHI)—AHI ≥2 indicative of OSA and AHI >10 indicates severe OSA in children (AHI ≥2 and >10, respectively, diagnostic for adults); McGill Oximetry Score measures nadirs of oxygen saturation during events and can alter category, regardless of AHI; any desaturation to <80% places child in severe category

Treatment: surgical intervention curative in ≤75% of children; children with craniofacial abnormalities or syndromic causes, and obese children without enlargement of lymphoid tissue, less likely to respond; sleep study may worsen immediately after surgery due to effects of anesthesia, opioids, and airway edema

Anesthetic management in children with OSA: at present, no standard protocol can be recommended; speaker advises reducing narcotics, using balanced anesthetic, and opting for regional anesthesia when possible; opioids—children with oxygen saturation <84% require half the dose of narcotics needed by those without OSA; children with OSA may benefit from maintenance of spontaneous ventilation and titration of narcotics to respiratory rate

Perioperative pain management: multiple modalities available; α-2 agonists—clonidine and dexmedetomidine (Precedex) available for humans; preserve cross-sectional area of airway; pain scores, opioid consumption, and incidence of emergence delirium reduced in children who received dexmedetomidine, but time to extubation (1 min) and time to discharge from post-anesthesia care unit (PACU; 10 min) longer; no studies have tracked pain response during first 24 hr; side effects—bradycardia; hypotension (warn PACU nurses); hypertension after bolus dosing more common than in adults (more pronounced in younger children)

Ketorolac: not often used due to risk for post-tonsillectomy bleeding (discuss with surgeon before administering); data promising in children; no difference seen between morphine and ketorolac in pain relief during first 2 to 4 hr
postoperatively; higher incidence of failed pain control seen in morphine group; optimal dose 1 mg/kg, but most providers use 0.5 mg/kg because of risk for bleeding (antiplatelet effect) and renal insufficiency (inhibition of prostaglandin); limit use to 3 days and switch to oral preparation when tolerated

**Acetaminophen**: IV preparation available and useful for relief of mild to moderate pain; medication orders from surgeon should be reviewed to avoid toxic levels of acetaminophen

**Ketamine**: preserves airway patency; data suggest opioid consumption reduced in patients with chronic pain; patients who received 0.5 mg/kg during induction of anesthesia for tonsillectomy and adenoidectomy had reduced pain scores and opioid consumption for first 24 hr (but no association shown with other surgical procedures); local infiltration of tonsillar bed with ketamine reduces pain scores for first 24 hr

**Codeine**: contraindicated in pediatric patients undergoing tonsillectomy and adenoidectomy due to case reports of respiratory arrest and death (black box warning)

**Postoperative admission**: 23-hr stay recommended; specific indications for admission not clear; children with severe OSA require overnight stay after general anesthesia or administration of opioids; young children with known OSA more likely to experience complications; speaker’s institution admits all children having tonsillectomy or adenoidectomy with age ≤2 yr, known OSA, or mild to moderate OSA and other comorbidities; continuous (monitored) pulse oximetry provided during admission

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To submit a test form by mail or fax, complete Pretest section before listening and Posttest section after listening.

1. The size of the da Vinci robot is a major limitation to its application in:
   (A) Otolaryngology head and neck surgery
   (B) Neurosurgery
   (C) Gynecology
   (D) Pediatric surgery

2. What level of muscle relaxation should be maintained during robotic surgery?
   (A) No relaxation necessary
   (B) ≤2 twitches
   (C) No twitches
   (D) ≥3 twitches

3. Choose the true statement about anesthetic management of patients undergoing robotic surgery.
   (A) There is often concern about diastolic function and cardiac output in patients with American Society of Anesthesiologists’ physical status 2
   (B) Administration of fluids must be minimized in patients undergoing pyeloplasty
   (C) Access to the patient’s airway may difficult, and is often 90° to 180° away
   (D) Repositioning of the patient and/or robot arms during the procedure is standard procedure

4. Which of the following anesthetic management techniques is(are) helpful during robotic surgery?
   (A) Placement of oximetry probe on the earlobe
   (B) Avoiding placement of orogastric tubes
   (C) Maintenance of normocarbia
   (D) All the above

5. Long operating times associated with robotic surgery contribute to all the following complications, except:
   (A) Hypertension
   (B) Rhabdomyolysis
   (C) Compartment syndrome
   (D) Cerebral edema

6. Which of the following is the strongest predictor of pediatric obstructive sleep apnea (OSA)?
   (A) Daytime sleepiness
   (B) Snoring
   (C) Combined snoring and bedwetting
   (D) Nighttime coughing

7. Pediatric OSA is most commonly encountered in which of the following age groups?
   (A) 2 to 6 yr
   (B) 6 to 10 yr
   (C) 12 to 15 yr
   (D) 17 to 21 yr

8. Which of the following screening results would indicate that an individual has severe sleep apnea?
   1. Apnea-hypopnea index (AHI) of 5 in a child
   2. AHI of 15 in an adult
   3. AHI of 11 in a child
   4. AHI of 4 and one desaturation to 79% in a child
   5. AHI of 32 in an adult
   (A) 1,2
   (B) 2,3,4
   (C) 3,4,5
   (D) 1,3

9. Which of the following statements applies to the use of ketorolac for management of pain after tonsillectomy?
   (A) Used infrequently due to increased risk for bleeding
   (B) Associated with risk for bradycardia
   (C) Pain relief during first 2 to 4 postoperative hours inferior to that with morphine
   (D) Safe for children with renal insufficiency

10. Which of the following medications has a black box warning and should be avoided for postoperative analgesia after tonsillectomy or adenoidectomy?
    (A) Morphine
    (B) Fentanyl
    (C) Hydrocodone
    (D) Codeine

Answers to Audio-Digest Anesthesiology Volume 56, Issue 15: 1-C, 2-B, 3-A, 4-C, 5-D, 6-B, 7-D, 8-B, 9-A, 10-C