Early Extubation After Cardiac Surgery

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Importance of early extubation after cardiac surgery (CS): early extubation associated with shorter stay in intensive care unit (ICU) and reduced cost; coronary artery disease estimated to cost $200 billion annually in United States; percutaneous coronary intervention and coronary artery bypass grafting (CABG) cost $12 billion annually; heart disease by far largest contributor to health care costs

Challenges in managing patients undergoing CS: cardiopulmonary bypass makes CS different from other operations; longer bypass time associated with higher rates of complications; cardiopulmonary bypass causes coagulopathy, hypotension, and inflammation; prime circuit with fluid (typically 4 mL/kg) for obligatory fluid load to patient; fluid repletion typically required intraoperatively and postoperatively; fluid retention occurs in kidneys; polyuria results from hypothermia and administration of mannitol

Goals of CS: general goals of surgery include bypassing diseased vessels, replacing diseased valves, and improving quality of life; postoperative goals — admit to ICU; warm patient; try to extubate <6 hr; patient spends night in ICU; wean vasopressor agents; remove chest tubes and lines; transfer to stepdown unit ≤24 hr

Admission to ICU: complex process involving multiple personnel (eg, anesthesiologist, cardiac surgeon, intensivist, nursing, and respiratory therapy); phases arrival, transfer of care, initial assessment, and treatment

Respiratory criteria for extubation: assess adequacy of ventilation — auscultation, oxygenation, and arterial blood gases (ABGs); in fast-track cardiac surgery ABGs may not be necessary (use pulse oximetry); chest radiography — look for signs of obvious pathology; ventilation — patient usually placed on support or assist control until spontaneously breathing; tidal volume should be no more than 6 to 8 mL/kg; positive end-expiratory pressure 3 to 8 cm H2O; apply pressure support, use lowest amount of oxygen necessary; criteria for early extubation — pulse oximetry >92% on Fio2 <50%; uncomplicated patients may be judged clinically, eg, if patient able to follow commands, mentating normally, and no history of problems with airway, can be extubated

Cardiovascular criteria for extubation: acceptable heart rate; temporary pacemaker set to synchronous mode; mean arterial pressure goal 65 to 85 mm Hg; cardiac index >2.2 (if less, investigate for cause); if balloon pump in place, confirm proper positioning; patients may be extubated with balloon pump in place if neurologically intact, breathing spontaneously, and able to lie flat; criteria for early extubation — adequate stable blood pressure with adequate perfusion; may be on low doses of vasopressors; free of arrhythmias; arrhythmias — most patients undergoing CS have arrhythmias; 30% develop atrial fibrillation; if accompanied by hypotension or rapid ventricular response, treat with magnesium or amiodarone; may apply cardioversion if accompanied by hypotension

Other criteria: bleeding and fluids — check for and treat any coagulopathy; patient usually warmed before checking coagulation profile; output from chest tubes used to check for active bleeding (increasing output cause for concern); volume losses replaced; temperature — goal to rewarmed to >36°C; some studies uphold safety of >35.5°C; clinically, should have absence of shivering; core temperature measured from bladder, esophagus, or pulmonary artery; other overall criteria — chest radiography with no pathology; patient neurologically intact; anesthetists reversed; some studies suggest that reversal of paralytic agents after patient warmed helps attain earlier extubation

Challenges: aging population with many comorbidities; advanced heart disease; complex procedures; early extubation applicable to patients undergoing aortic valve replacement; however, those undergoing more complex procedures (eg, heart transplantation, redo surgery, replacement of multiple valves and bypass, surgery of aorta, deep hypothermic circulatory arrest) should be kept intubated

Clinical pathways: fast-track cardiac anesthesia — aims to extubate patients 1 to 6 hr after arrival at ICU; fast-track cardiac surgical plan — attempts to improve efficiency of care (includes minimally invasive techniques, eg, robotic surgery); clinical pathways — integrated management that includes order sets with time-specific goals; pathway covers entire hospital stay; represents evidence-based medicine; requires working group including cardiac surgeons and cardiac anesthesiologists; pathway should be established for early extubation; establishing pathways through consensus prevents omissions, variations, and duplications; amenable to collection and evaluation of data; decreases documentation; reduces length of stay and cost

Data on early extubation: reduces morbidity and mortality, ventilator-associated pneumonia, and central line-associated bloodstream infections (with longer ICU and hospital stays),

Educational Objectives

The goal of this program is to improve the anesthetic management of patients undergoing cardiac surgery and patients requiring preoxygenation and apneic oxygenation. After hearing and assimilating this program, the clinician will be better able to:

1. Identify criteria for early extubation of patients after cardiac surgery.
2. Evaluate the key features of fast-track cardiac anesthesia programs.
3. Determine the role of preoxygenation.
4. Explain the physiology of apneic oxygenation.
5. Formulate a treatment plan for using preoxygenation and apneic oxygenation.

Faculty Disclosure

In adherence to ACCME Standards for 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, members of the faculty and planning committee reported nothing to disclose.
and promotes earlier rehabilitation and discharge; Silbert et al (1998) — randomized 100 patients undergoing elective CABG to either fentanyl 50 µg/kg or fentanyl 15 µg/kg; patients given the lower dose extubated in shorter time without major complications; Hansschen et al (2012) — retrospectively reviewed 5300 patients selected preoperatively for fast-track program; 84% successfully extubated in postanesthesia care unit (PACU) and discharged to stepdown unit; Cheng et al (2003) — prospectively randomized 120 patients to conventional vs fast-track cardiac anesthesia program (latter included lower doses of fentanyl during induction and avoidance of benzodiazepines before bypass); concluded that fast-track approach safe and reduced total hospital cost; Curtis et al (2013) — retrospective study demonstrated that dexmedetomidine (Precedex) associated with earlier extubation and shorter length of stay than propofol; Vance et al (2014) — randomized ≥300 patients to anesthesia guided by either bispectral index monitoring or monitored anesthesia care; monitoring by BIS did not change time to extubation or decrease length of stay in ICU or hospital; Probst et al (2014) — randomized patients after cardiac surgery to recovery in either ICU or postanesthesia care unit (PACU); median time to extubation in patients assigned to PACU 90 min, vs 478 min in ICU; Fitch et al (2014) — studied 2000 patients undergoing cardiac surgery at Johns Hopkins during 3 sequential time periods; first period utilized baseline practices; second involved protocol devised by multidisciplinary team to achieve early extubation; last time period used protocol and added reversal of paralytic agents and posting of sheets for time-specific extubation; use of standardized protocol improved early extubation; patients in last period extubated earlier because of improved team approach; presence of staff also made it more acceptable.

Cochrane Collaboration: concluded that fast-track care for adult patients undergoing cardiac surgery reduces time to extubation and shortens length of ICU stay but does not reduce length of hospital stay.

Suggested Reading


The Essentials of Preoxygenation and Apneic Oxyenation

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Challenges of apnea: most often, incidents of apnea anticipated; ie, occurs with use of propofol and paralytic agents; occurs with rigid bronchoscopy, management of central airway obstruction, thoracic surgery, resection of trachea, balloon dilation of tracheal stenosis, and electroconvulsive therapy; unexpected apnea may occur with laryngospasm or loss of airway; tools for management — clinical judgment; assessment of airway; awareness of available tools; preoxygenation; apneic oxygenation

Physiology: oxygen-hemoglobin dissociation curve — when oxygen saturation <90%, patient at high risk for precipitous drop with concomitant extremely low oxygenation of tissues; oxygen saturation of 70% associated with high risk for arrhythmias, hemodynamic compromise, brain injury, and death; for patients breathing room air (normal Pao2 90-100 mm Hg), clinically important desaturation begins after only 45 to 60 sec of apnea; preoxygenation developed in 1950s to increase period of safe apnea; goal to reach oxygen saturation of 100%, to denitrogenate lungs, and if possible, to denitrogenate blood; when breathing 21% oxygen, 450 mL of oxygen in lungs, with total reservoir of oxygen 1 to 1.5 L; when preoxygenation done well, oxygen in lungs can be increased to 3 L, and total reservoir to 4 L; time from optimal preoxygenation to desaturation to 90% — 8 min in healthy 70-kg adult; 5 min in moderately ill adult; 2.5 to 3 min in adult with obesity or in child

Preoxygenation: Baraka et al (1999) — compared tidal volume breathing for 3 min with high FiO2 to various tidal-capacity protocols for 30 or 60 sec; 3 min of tidal volume breathing achieves Pao2 of ≥390; 8 tidal-capacity breaths in 60 sec achieves same result; flow of oxygen — when using standard nonrebreathing mask, must increase flow; 15 L/min of oxygen flow delivers FiO2 of only 0.6 to 0.7; increase flow to ≥30 L to reach FiO2 ≥0.9; positive pressure ventilation (PPV) — important tool with morbidly obese patients; French study of 66 patients in whom oxygenation by standard preoxygenation could not achieve saturation ≥95% compared control group to noninvasive PPV group to group that received noninvasive PPV plus recruitment maneuver, performed after endotracheal intubation; demonstrated that in obese patients noninvasive PPV improves oxygenation; Pao2 additionally improved after endotracheal intubation; recruitment maneuver also significantly improved results; concluded that PPV during preoxygenation in patients with morbid obesity increased safe apnea period

Positioning of patient: atelectasis of dependent portions of lungs leading cause of hypoxia in OR; studies indicate that placing patients in reverse Trendelenburg position or raising head of bed 20° to 25° beneficial; in one study, raising head of bed 25° for preoxygenation increased time to desaturation from 100% to 95% by almost 2 min; in study on obese patients, ≥1 min gained.

Choice of paralytic agent: use of rocuronium emulates conditions for intubation created by succinylcholine, but requires relatively high dose (eg, 1.2 mg/kg); effect lasts longer; influence on safe apnea period — succinylcholine causes muscle fasciculations, which result in high metabolic demand, consumption of oxygen, and shorter time to desaturation; involves much higher end-tidal CO2; avoids effects by administering lidocaine or fentanyl, which reduce fasciculations; can achieve similar effect with small dose of nondepolarizing agent before succinylcholine

Preoxygenation in critically ill patients: small changes in cardiac output, hemoglobin, metabolic demand, and alveolar oxygen tension result in large changes in safe apnea period; reduced effect of PPV common in critically ill patients; study demonstrated that in average ICU patients, desaturation to 85% occurred in 23 sec, vs 500 sec in normal 70-kg adult; average Pao2, 67, and increased to only 104 after 4 min of preoxygenation; in critically ill patients, preoxygenation maneuvers only marginally effective

Pediatric patients: normal 10-kg child more closely resembles adult with morbid obesity than normal adult; Kerrey et al (2012) deployed video camera in emergency department and videotaped 114 rapid-sequence inductions in children (mean
Apneic oxygenation: alveoli take up oxygen in absence of respi-
rations through passive diffusion (based on favorable solubility of
oxygen and its very high affinity for hemoglobin; average of
250 mL of oxygen/min can diffuse from alveoli to blood,
while only 8 to 20 mL of CO2/min move from blood to alveoli;
results in development of subatmospheric pressure in alveoli,
with mass flow of gas from pharynx to alveoli; under ideal con-
ditions, able to maintain Pao2 >100 for >100 min; CO2 accu-
mulation results in severe hypercarbia and respiratory acidosis,
but usually tolerated well if patient sufficiently oxygenated
Clinical applications of apneic oxygenation: used for exami-
nation of brain death, bronchoscopy, otolaryngologic proce-
dures, thoracic procedures, and tracheal intubations; Taha et
al (2006) — employed 4 deep breaths over 30 sec and then
applied apneic oxygenation via nasal cannula (5 L/min); com-
pared with control patients not given supplemental oxygen;
control group desaturated to 95% after mean time of 3.65
min, while study group maintain 100% oxygenation for entire
observational period (6 min); morbid obesity — study analyzed
patients after 8 vital capacity breaths over 60 sec who either
received or did not receive apneic oxygenation; remarkable
difference in time to desaturation to 95%; ventilation during
apneic period — speaker uses PPV because cricoid pressure
should prevent air from distending stomach
Techniques for apneic oxygenation: typically employs nasal
cannula using 6 L/min of flow and bubble humidifier; posi-
tioning of patient — crucial for avoiding airway obstruction;
place patient in sniffing position (especially important in
obese patients); nasal airway may be added if concerned about
obstruction
Conclusions: apply preoxygenation with head of bed 20° to 25°
or patient in reverse Trendelenburg position; place nasal can-
naula, but not initially attached to oxygen; start nonrebreather
mask on high flow rate; if unable to increase oxygen >90%,
consider adding PPV; preoxygenate with 3 to 5 min of tidal
volume breathing or 8 vital capacity breaths over 60 sec with
high Fio2; consider delayed-sequence induction in children
who cannot tolerate preoxygenation; during apneic period
pay attention to positioning to maintain patency of airway; if
using succinylcholine, add agent to modify fasciculations; pro-
vide high flow of oxygen by nasal cannula; provide additional
PPV in high-risk patients; maintain apneic oxygenation during
intubation

Suggested Reading
Baraka AS et al: Preoxygenation: comparison of maximal breathing and
tidal volume breathing techniques. Anesthesiology 1999 Sep;91(3):612-
6; Benumof JL: Preoxygenation: best method for both efficacy and
efficiency. Anesthesiology 1999 Sep;91(3):603-5; Kerrey B et al: Rapid
sequence intubation for pediatric emergency patients: higher frequency
of failed attempts and adverse effects found by video review. Ann Emerg
Med 2002 Sep; 60(3):251–259; Taha SK et al: Nasopharyngeal oxygen
insufflation following pre-oxygenation using the four deep breath tech-

Acknowledgments
Dr. Ratzlaff spoke at Survey of Current Issues in Surgical Anesthesia, presented by the Cleveland Clinic Anesthesiology Institute and held December 1-5, 2014, in Naples, FL. For information on upcoming CME meetings from the Cleveland Clinic Anesthesiology Institute, please visit ccfme.org. Dr. Meiler spoke at Airway on the Island: A Multidisciplinary Approach to Airway Management, presented by the Medical College of Georgia at Georgia Regents University and held August 14-16, 2014, in Kiawah Island, SC. For information on upcoming CME meetings from the Medical College of Georgia at Georgia Regents University, please go to gru.edu/ce/medicalse, or visit our website, Audiodigest.org, and click on “Upcoming Meetings.” The Audio Digest Foundation thanks the speakers and the sponsors for their cooperation in the production of this program.

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1. Respiratory criteria for early extubation after cardiac surgery include pulse oximetry of _______ on Fio2 _______.
   (A) >95%, <50%  (C) >90%, <50%
   (B) >92%, <50%  (D) >90%, <40%

2. Which of the following is NOT among the cardiovascular criteria for early extubation?
   (A) Adequate stable blood pressure with adequate perfusion
   (B) Patient may be on low doses of vasopressors
   (C) Patient free of arrhythmias
   (D) Balloon pump not present

3. After which of the following procedures may early extubation be performed once safety criteria are met?
   (A) Redo cardiac surgery  (C) Surgery of the aorta
   (B) Aortic valve replacement  (D) Heart transplantation

4. One of the goals of fast-track cardiac anesthesia is to extubate the patient _______ after arrival at the ICU.
   (A) ≤6 hr  (B) ≤10 hr  (C) ≤12 hr  (D) ≤16 hr

5. A retrospective clinical study found that use of which of the following reduced time to extubation after cardiac surgery?
   (A) Midazolam  (C) Dexmedetomidine
   (B) Propofol  (D) Bispectral index monitoring

6. In a patient breathing room air, an apnea time of _______ typically leads to clinically important desaturation.
   (A) 25 to 30 sec  (C) 80 to 90 sec
   (B) 45 to 60 sec  (D) 105 to 120 sec

7. In a normal healthy adult weighing 70 kg, the time from optimal preoxygenation to desaturation to 90% is:
   (A) 3 min  (B) 4 min  (C) 6 min  (D) 8 min

8. When a nonrebreathing mask is used, an oxygen flow rate of 15 L/min delivers an Fio2 of:
   (A) ≈0.4  (C) ≈0.8
   (B) ≈0.6  (D) ≈0.9

9. In critically ill adult patients, preoxygenation maneuvers are _______ in normal adult patients at increasing time to desaturation.
   (A) More effective than
   (B) Less effective than
   (C) About equally as effective as

10. Under ideal conditions, apneic oxygenation is able to maintain a Pao2 of >100 for:
    (A) >10 min  (B) >30 min  (C) >60 min  (D) >100 min

Answers to Audio Digest Anesthesiology Volume 57, Issue 47: 1-A, 2-B, 3-C, 4-C, 5-D, 6-C, 7-D, 8-B, 9-A, 10-B

NOTE: On Audio Digest Anesthesiology Volume 57, Issue 37, all answers to question 2 will be accepted.