Extuation after General Anesthesia: Adults and Pediatric Deep or Awake

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Incidence of airway complications associated with deep extubation in adults

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Background

- Endotracheal extubation is the final and arguably the most crucial step during emergence from general anesthesia (GA).
- Normally, it is carried out when patients are awake with return of airway reflexes.
- However, extubations can also be accomplished while patients are deeply anesthetized but maintaining spontaneous breathing, a technique known as “deep extubation”.
- Deep extubation is frequently performed in the setting of eye surgery as well as head and neck surgery.
- The intention is to minimize bucking and limit increase in intraocular and intracranial pressure

Background

- many anesthesiologists are still reluctant to perform deep extubation in adults because of concerns for potential respiratory complications.
- This apprehension may be unfounded as most published experiences (and reported complications) center around pediatric patients and not adult patients.
- To our knowledge, there have only been a couple of adult deep extubation studies, with around 30 patients in each arm, comparing respiratory complications in patients deeply extubated after inhaled anesthetics with and without adjuvants .

Background

- Therefore, in this prospective observational cohort study, we set out to assess the rate of respiratory complications after deep extubation in a larger sample size of 300 adult patients undergoing ocular and head and neck surgery.
- Our goal was to determine if there are intraoperative factors that may influence the success of deep extubations.

Methods
Study population

- This single arm, unblinded, observational study was approved by the Institutional Review Board (IRB) of Massachusetts Eye and Ear Infirmary, Boston, Massachusetts(#1047249).
- Patients greater than 18 years of age at the time of surgery and selected by the anesthesiologist as a candidate for deep extubation were enrolled in this study without specific exclusion criterion.
- All patients were evaluated by the preoperative anesthesia staff prior to surgery and a detailed preoperative note detailing vital signs, health history, and airway assessment (Mallampati score I-IV, neck ROM, TM distance, mouth opening, and artificial airway, facial hair, dental exam) was documented in the electronic medical record.
- Over the course of six months, 300 patients were enrolled in this observational study.

Methods

- Each day during this six-month period, a research coordinator would report to the main operating room and determine the possible candidates for the day based on age and anesthetic plan.
- Towards the end of each surgery the research coordinator would ask each anesthesiologist utilizing inhalation anesthetics about the extubation plan.
- If the anesthesiologist selects the patient for deep extubation, the patient would be followed from the end of surgery to Post Anesthesia Care Unit (PACU) for data collection.
- The deep extubation technique was the only controlled procedural variable among our patient cohort; other anesthesia procedural variables were selected at the provider's discretion.

Anesthetic management

- At the end of the case, the fraction of inspired oxygen (FiO2) was increased to 100% and the end inspired concentration of inhaled anesthetic was adjusted to be at least 1 Minimum Alveolar Concentration (MAC) or higher if needed.
- The depth of anesthesia was considered adequate clinically when the patient was spontaneously breathing with a regular pattern, at a MAC of 1 or higher, and if the patient did not exhibit any response to suctioning and to deflation and reinflation of the endotracheal tube cuff.
- Before extubation, an oral airway was placed in all the patients, and jaw thrust was applied if needed after extubation.
- The oral airway was removed, either in the operating room by anesthesia provider or in PACU by trained PACU nursing staff with 1-to-1 nurse to patient ratio under the supervision of an anesthesiologist, when the patient regained airway reflexes.
- Patients were administered oxygen at 6 L/min, via a face mask; supplemental oxygen was discontinued in PACU as per usual recovery room management.

Methods

- For comparison, patients were classified into two groups:
- those without respiratory complications
- those with respiratory complications as defined by persistent coughing, desaturation measured by saturation of peripheral
- oxygen (SpO2) by pulse oximetry of less than 90% for
- longer than 10s, laryngospasm, stridor, bronchospasm,
- and reintubation.

Results

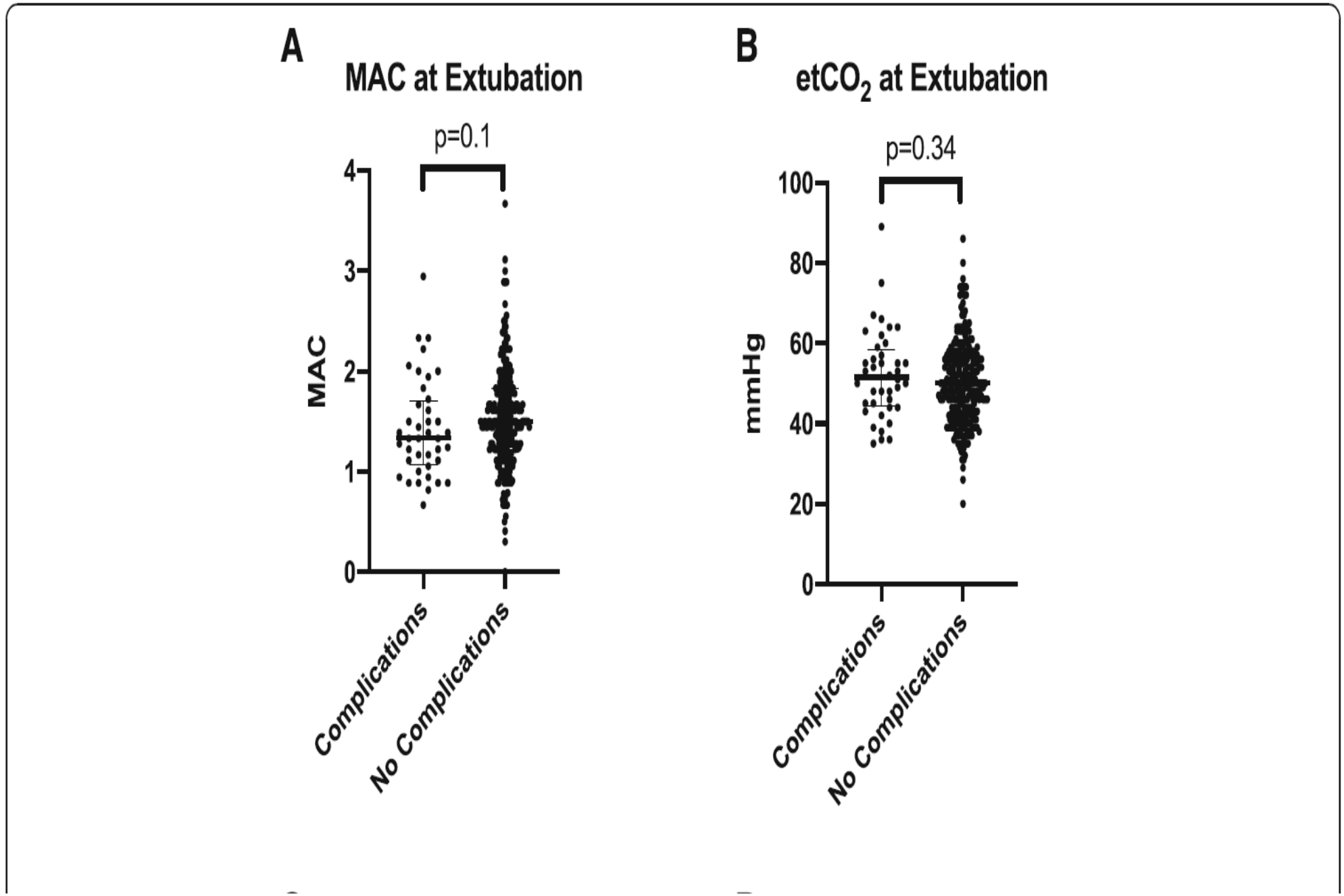
- A total of 300 adult patients were recruited for the study.
- Among them, 40 (13%) patients had at least one complication in the OR post deep extubation that included persistent coughing, desaturation SpO2 < 90% for longer than 10s, sore throat, laryngospasm, stridor, bronchospasm
- None of the 300 patients required re-intubation

Results

- When comparing patient's demographic of the complications group to the no complications group, there were no differences in patient age (50.0(34.4–60.5) vs 50.0(30.3–52.0), p = 0.9506) and sex.
- In contrast, patients in the complications group had significantly higher BMI (30.0(25.3–35.0) vs 26.0(23.0–29.0), p < 0.0001) when compared to the no complications group.
- We observed no significant difference in patient ASA PS classification or type of surgery class (ear, eye, neck, nose, throat, thyroid) .
- Furthermore, there were no significant differences in rates of pre-existing respiratory pathology, Mallampati Score, Cormack and Lehane's classification between complications and no complications groups .
- Lastly, all the patient were able to be masked.

Results

- Anesthetic depth did not appear to impact complications at the time of extubation MAC (1.33(1.07–1.71) vs 1.50(1.22–1.83, p = 0.1002), nor did etCO2 (51.5(44.3– 58.5) vs 50.0 (43.0–57.0), p = 0.3352)
- patient percent O2 saturation levels are significantly lower for the complication group compared to the no complications group at 5 mins before deep extubation (99.0(97.3–100) vs 100 (99.0–100), p = 0.0023)
- The time from deep extubation to leaving the OR was longer, at 12.0(9.00–14.8) mins, in the complications group compared to 9.00(7.00–13.0) mins in the no complications group (p = 0.0098)
- The time to eye opening was also longer in the complications group than the no complications group (15.0(9.00–21.0) vs 18.0(13.3–25.0), p = 0.0036)
- The total intraoperative opioid use and muscle relaxant and reversal use are not significantly different between the two groups


A
MAC at Extubation
p=0.1
MAC
4
3
2
1
0
Complications
No Complications
B
etCO2 at Extubation
p=0.34
mmHg
100
80
60
40
20
0
Complications
No Complications

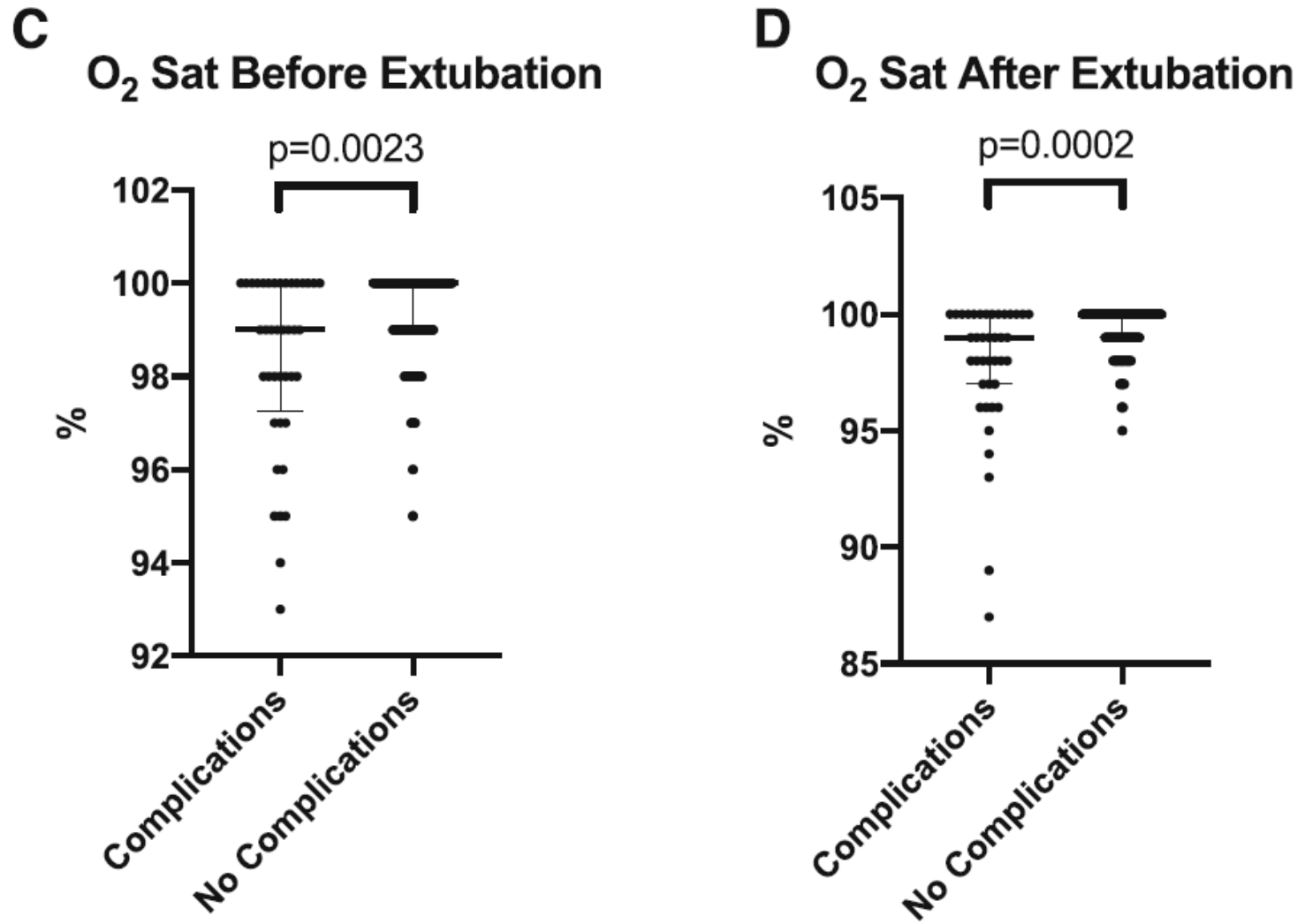


Fig. 3 Comparison of emergence conditions between complications versus no complications groups by **a** MAC, **b** end-tidal CO_2 ($etCO_2$), (C) O_2 Saturation (Sat) before and (D) O_2 Sat after extubation

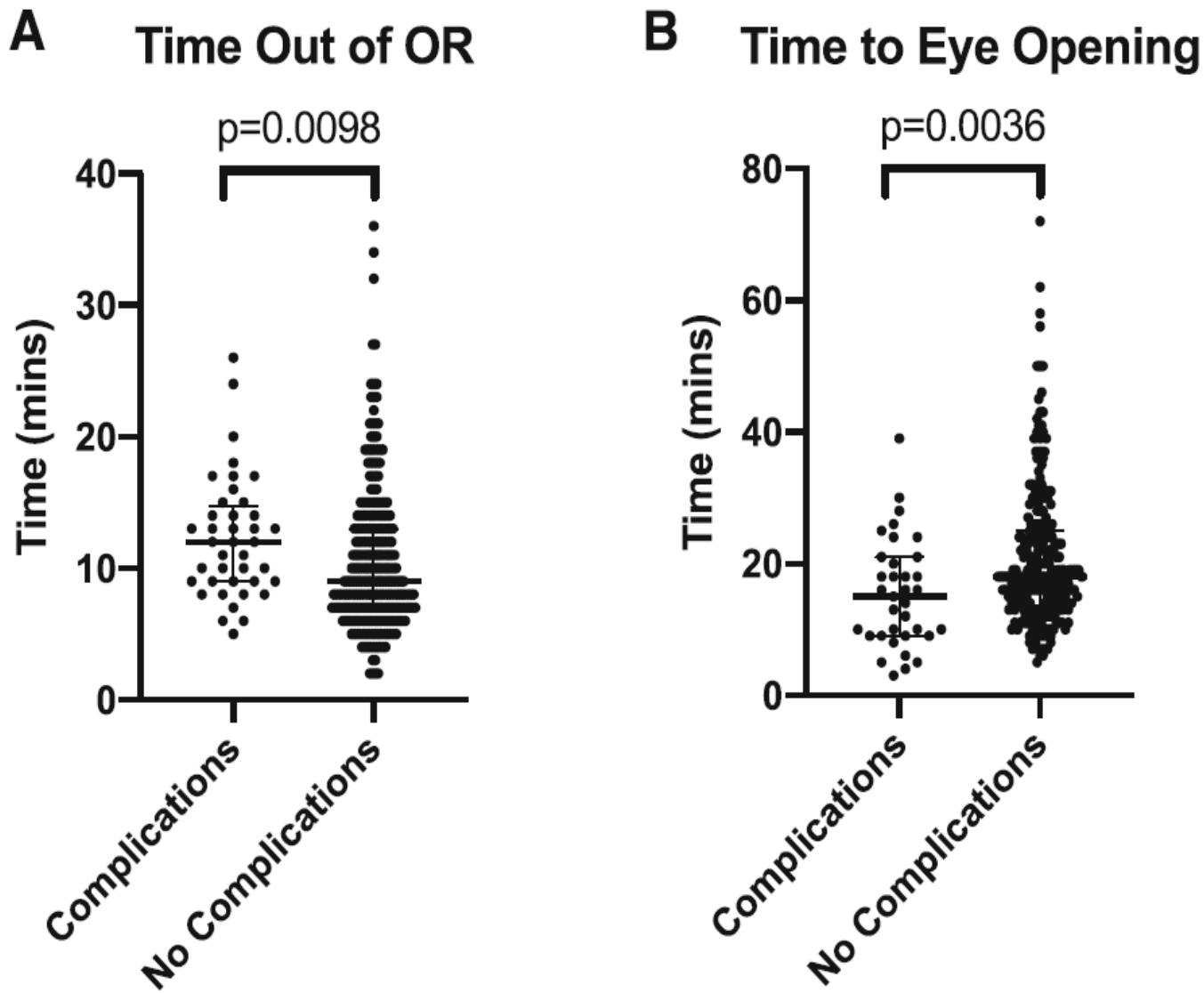


Fig. 4 Comparison of emergence times between complications versus no complications groups from end of surgery to **a** time out of OR and from extubation to **b** time to eye opening

Discussion

- In this study, 13% of adult patients (40 out of 300) had at least one or more respiratory complications with deep extubation.
- This is within range of a previous publication by Kim and colleagues in which one group that received desflurane had a 48% complications rate (12 out of 25 patient) while the other group that received desflurane with remifentanil had a 3.4% complication rate (1 out of 29 patients) .
- It is also consistent with Fanet al's report, where percentage of patient with airway complications ranges from 12 to 37.5%

Discussion

- It is well understood that deep extubation can minimize adverse hemodynamic reflexes in appropriate situations .
- Nonetheless, many anesthesiologists are reluctant to perform deep extubation in adults because of concerns for potential respiratory complications .
- The present study indicates that deep extubations in adults is likely safer than in the pediatric population.
- Our airway complication rate of 13% in adult patients is significantly lower than the 40% complication rate (64 out of 159 patients) reported in a recent meta-analysis of pediatric patients.
- While it is possible that patient selection and provider difference account for the lower rate; it is also conceivable that the pediatric airway is more irritable and sensitive to stimulation than the adult airway.

Discussion

- Present study suggests that patient selection plays an integral part in the success of endotracheal deep extubations.
- Our anesthesia providers selected patients for deep extubations per clinical discretion without predetermined criterion.
- Overwhelmingly, the patients selected had easy airway placement based on the Cormac and Lehane's Grade as only 1 patient out of 300 had a grade 4 view, which is a probable factor contributing to an overall complications rate near the lower limits of previously published ranges .
- Our data also shows that when the provider chose to deep extubate patient with lower O2 saturation levels 5 mins prior to extubation, these patients are more likely to have significant airway complications.
-

Discussion

- Our results suggest that higher BMI patients are less likely to tolerate deep extubations.
- We observed a statistically significant correlation between higher BMI and likelihood of complications during deep extubation.
- The median BMI in the complications group was 30 while the median BMI in the no complications group was 26.
- Obesity has been shown to worsen oxygenation through several mechanisms, including increased intra abdominal pressure and atelectasis .
- Whether an isolated elevated BMI is a causal factor for complications during deep extubations will need further investigation.

Discussion

- The depth of anesthesia suitable for a smooth deep extubation is primarily based on the MAC of inhaled anesthetics.
- Previous studies suggested that extubation could be performed at an inhaled anesthetic level as low as 1 MAC .
- Some of the differences in MAC levels were likely due to variations in adjuvant opioid use, because opioid medications have been shown to minimize coughing and various extubation related adverse events .
- Here, we allowed the providers to freely decide the type and amount of opioid use appropriate for practice and did not observe a significant difference in the amount of opioid used in the complications versus no complications groups.

Table 1 Comparison of intraoperative dose of medications. Drug name (dosing unit) are listed in the left column. Data are expressed as median (q1-q3)

Drugs	Complications (*n* = 40)	No Complications (*n* = 260)	*P*-Value
Fentanyl (mcg)	100 (0.0–100.0)	100 (0.0–100.0)	0.3674
Remifentanil (mg)	0.580 (0.15–0.973)	0.435 (0.100–0.960)	0.3133
Morphine (mg)	0.0 (0.0–2.0)	0.0 (0.0–2.0)	> 0.9999
Hydromorphone (mg)	0.200 (0.00–0.900)	0.00 (0.00–0.500)	0.3374
Rocuronium (mg)	10.0 (0.00–10.0)	10.0 (0.00–10.0)	0.5999
Succinylcholine (mg)	100 (0.00–100)	80.0 (0.00–100)	0.6332
Neostigmine (mg)	0.00 (0.00–0.00)	0.00 (0.00–0.00)	0.5735

limitations to this study

- There were several limitations to this study.
- Firstly, this is a single-center prospective study, and the anesthesiologists were not and could not be blinded to the treatment technique.
- Secondly, there is also significant selection bias in the study, as no patients with history of difficult airway underwent deep extubation.
- Thirdly, other than the deep extubation technique, the anesthetic management was not standardized.
- However, this is a reality of every day anesthesia practice, irrespective of the extubation technique.
- Lastly, an experienced anesthesia provider remained with each patient until an adequate control of the airway was achieved, which could have contributed to the low incidence rate of complications.

Extubation of Pediatric patients after General Anesthesia

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Extubation of Pediatric Patients Following General Anesthesia

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Introduction

- Extubation in adults and children varies in two significant ways.
- The first:
- Adults in many cases are much more heterogeneous population in term of their cardiovascular and pulmonary health, and this can have significant implications for rate of success.
- The other primary difference is adults increased cognitive ability and capacity to process environmental information in a useful way, compared with infants and younger children.

Awake Extubation in Routine Pediatric Patients

- Criteria which are routinely used by clinicians around the world, Included:
- Tidal volume more than 5ml.kg
- Movement other than coughing
- Purposeful movement
- Conjugate gaze,
- eye opening,
- low end tidal agent concentration,
- oxygen saturation greater than 97%,
- and a positive laryngeal stimulation test.

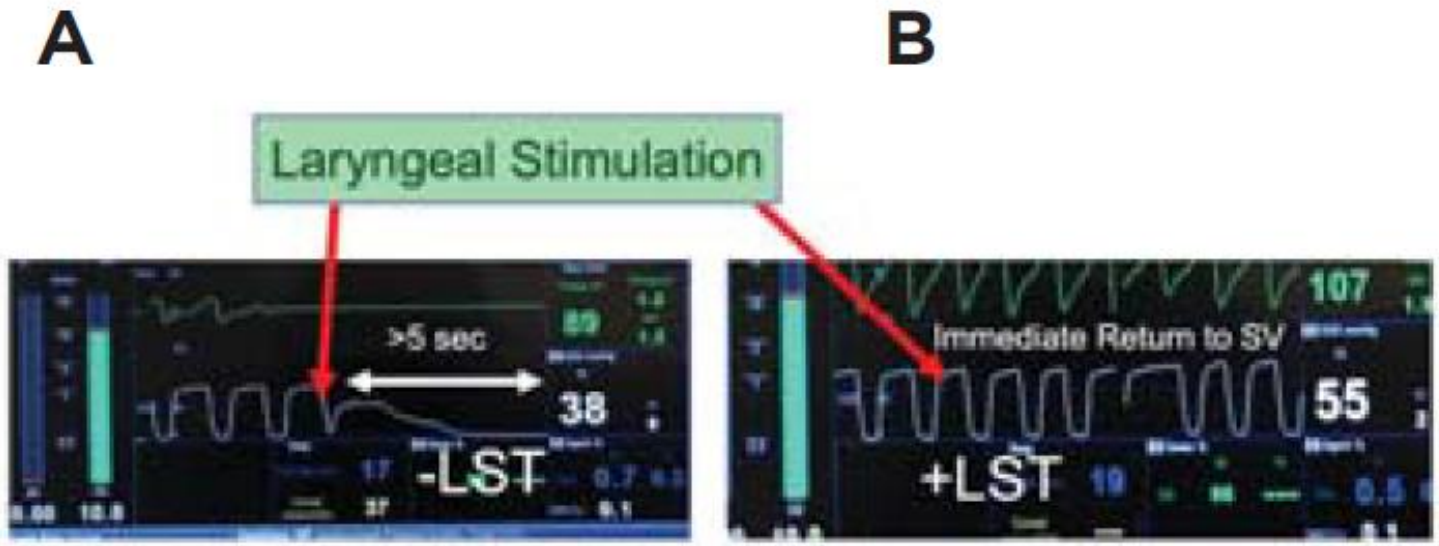

Figure. End-tidal carbon dioxide tracings of a positive and negative laryngeal stimulation test (LST).

A. Negative LST is one in which there is a respiratory pause of more than five seconds following laryngeal stimulation.

B. Positive LST is one in which the patient returns to spontaneous ventilation in less than five seconds following laryngeal stimulation.

Table 1. Top 5 Predictors of Successful Extubation

Conjugate gaze
Eye opening
Facial grimace
Purposeful movement
Spontaneous tidal volume >5 mL/kg

Table 2. Predictive Value of Increasing Number of Top 5 Extubation Criteria

Criteria Present Out of Five, n	Patients, n	Positive Predictive Value, %	How Often Clinician Will Be Wrong
1	112	88.4	1 in 8
2	164	88.4	1 in 8
3	163	96.3	1 in 27
4	114	97.4	1 in 38
5	30	100	Rarely

Study

- All criteria above checked during extubation and children graded according the quality of extubation:
- Successful, intervention required, major intervention required
- These verified predictors often occur in a foreseeable order: with most patients achieving Tidal volume more than 5ml.kg first, followed by Conjugate gaze, facial grimace, Purposeful movement and eye opening.
- Recent upper respiratory infection, premedication and end tidal carbon dioxide greater than 55 mmHg at the time of emergence and extubation required intervention.

Deep Extubation

- There is continuing debate in the pediatric anesthesia community on the merits of awake versus deep extubation.
- Reason:
- Lack of a standard definition of deep extubation
- Deep extubation: removing endotracheal tube at a deeper anesthetic plan where any airway reflex related to oropharyngeal or glottic stimulation have been completely ablated.
- Deep extubation can improve efficiency by basically shifting the time dedicated to extubation and emergence from the OR to the PACU.
- In a prospective randomized study deep extubation was associated with fewer perioperative respiratory adverse events (PRAE) in at risk patients
- Deep extubation had a higher risk for upper airway obstruction

Complications associated with extubation

- Complications are fairly common. T
- hese events include:
- Upper airway obstruction,
- apnea or breath-holding,
- Excessive coughing,
- desaturation,
- bronchospasm,
- laryngospasm.

Complications associated with extubation

- Simple remedies include performing a jaw thrust maneuver or applying 10 to 20 cm H2o continuous positive airway pressure (CPAP) via bag mask.
- The clinician should exercise caution when performing this maneuver to avoid stimulation of J receptor in the lung, which are sensitive to stretch and can lead to additional coughing and further desaturation.
- Other remedies include:

✓Placement an oral airway

✓Placing the child in the lateral position

Table 3. Summary of Near-Term Complications Associated With Extubation in Pediatric Patients

Complications	Cause	Diagnostic/Clinical Signs	Interventions
Apnea	• Oversedation with opioid • Hypocarbia ($EtCO_2$ <40) • Oversedation caused by synergism of multiple anesthetic agents including preoperative benzodiazepine and/or inhalational agent	• No spontaneous ventilatory effort • Able to mask-ventilate patients • $EtCO_2$ can be high or low • Small or pinpoint pupils • ↑ End-tidal potent inhalational agent concentration	• Bag mask ventilation to maintain SpO_2 >94% • Allow $PaCO_2$ to rise • Consider flumazenil or naloxone in recalcitrant situations
Bronchospasm	• Preexisting upper respiratory infection • Asthma • Bronchiole constriction • Routine exposure to secondhand smoke	• Persistent coughing • No breath holding • Wheezing on auscultation • ↓ SpO_2 although this is usually a late sign • ↑ CO_2	• Albuterol • Epinephrine 0.05 mcg/kg IV if extreme
Coughing/ breath-holding	• Preexisting upper respiratory infection • Premature extubation while patient is in stage 2 • Bronchiole constriction • Routine exposure to secondhand smoke	• Persistent coughing • Breath holding typically <10 seconds • ↓ SpO_2 • ↑ $EtCO_2$ caused by ↓ alveolar ventilation	• ↑ FiO_2 via mask • Apply CPAP with 10-20 cm H_2O • Overly aggressive CPAP can worsen • Attempt to wait for resolution • This will usually resolve with time as patient emerges further

Laryngospasm	• Premature extubation while patient is in stage 2 • Glottic closure from stimulation by endotracheal tube removal or secretions	• Usually preceded by cough • Rigid abdominal wall • Unable to mask-ventilate even with oral airway and elevated ventilatory pressures • Breath holding for >10 seconds • ↓ SpO_2	• Briefly attempt mask ventilation or apply CPAP with 100% FiO_2 • Propofol 1 mg/kg IV (repeat or escalate dose if initially unsuccessful) • Succinylcholine 1 mg/kg, 4 mg/kg IM if IV is infiltrated or pulled out • Reintubate if significant laryngospasm requiring more propofol or succinylcholine recurs
Upper airway obstruction	• Lack of oropharyngeal tone • Collapse of base of tongue and soft palate onto posterior pharyngeal wall • Oversedation with opioid or benzodiazepine • Residual inhalational agent • Underlying sleep-disordered breathing	• Patient appears to attempt to breathe but no breath sounds are present • Stemal notch sinks in with attempts at inspiration • ↓ SpO_2 • Loud upper airway noises with inspiration	• Jaw thrust • 10-20 cm H_2O of CPAP • Oral airway • Lateral position • Consider flumazenil or naloxone • Bag-mask ventilate patient with 100% FiO_2

CO_2, carbon dioxide; **CPAP,** continuous positive airway pressure; **$EtCO_2$,** end-tidal carbon dioxide; **FiO_2,** fraction of inspired oxygen; **IM,** intramuscular; **$PaCO_2$,** partial pressure of carbon dioxide; **SpO_2,** oxygen saturation

Complications associated with extubation

- Excessive coughing and bronchospasm are possible and, in some cases, can lead to desaturation.
- If the clinician suspect bronchospasm, it is typically just prior to extubation, and a dose of albuterol in to the endotracheal tube may improve ventilation after extubation.
- Laryngospasm (glottic closure), can result in hypoxemia and in some cases cardiac arrest.
- Exact mechanism under anesthesia is unknown, it is likely related to the interaction of potent inhalation agents with respiratory center and normal airway reflex arcs in the brainstem.
- It occur after extubation and will be heralded by a brief cough, followed by a period of apnea and frequently contraction of the abdominal wall muscles.

Treatment

- Apply 20 to 30 cmH2O of CPAP
- Administer 1 to 3 mg.kg propofol or 1 to 2 mg.kg succinylcholine
- Reintubation if laryngospasm occurs a second time and then waiting to extubate the patients until they have fully emerged
- If IV line has come out :
- 4mg.kg succinylcholine IM
- or 1mg.kg rocuronium IM

Extubation in higher risk pediatric patients

- 1: not extubate: patients on oxygen prior to surgery, weight less than 2 kg, history of respiratory distress, extreme prematurity, another significant comorbidity
- 2: NICU pre mature infants, which post conceptual age is near term with a less complicated surgery such as placement a central line, they had respiratory complications such as reintubation in the NICU, if they had extubation in the PACU (Weight<1.58kg, or PCA<41weeks)
- In addition infants with both of these two factors had an almost 7 times greater risk for a major respiratory events in the PACU.
- These infants should be extubated at a later point, in NICU.

Extubation of the known difficult pediatric airway

- Increased adverse outcome including:
- emergence tracheostomy,
- hypoxemic cardiac arrest,
- anoxic brain injury,
- death

Extubation of the known difficult pediatric airway:

❖Prior to any extubation attempt:

✓Patient should be positioned appropriately

✓Neuromuscular blockade should be reversed

✓Appropriate analgesia ensured

✓Temperature, cardiovascular, neurologic and metabolic status optimized

✓Hollow airway exchange catheters (ACEs) may be used (barotrauma)

✓Nasal canula and face mask

✓Supra glottic airway: air -Q(Cookgas) and i-gel(intersurgical)

✓LMA classic(Teleflex) also suitable

✓J-tipped wire catheters, ureteral stent, and guide wire sheaths

fast track" approach to cardiac surgery

- A "fast track" approach to cardiac surgery can be defined as a perioperative process involving rapid progress from preoperative preparation through surgery and discharge from the hospital.
- Although highly individualized among the various heart surgery centers, the fast-track process is a team activity.
- It requires a team of health care providers to interact with the patient at various phases, from admission to discharge.
- The necessary elements of the fast-track program are choice and the titration of short-acting anesthetic drugs, standardized surgical procedures, early extubation, rewarming and sustained postoperative normothermia, postoperative pain control, early ambulation, alimentation and discharge, and follow-up after discharge.

Fast-Track care of higher risk pediatric patients

- Rapid reestablishment of normal physiologic condition,
- fewer ventilator associated complication,
- reduction for sedative requirement and less hemodynamic compromise,
- earlier start of enteral nutrition,
- interaction with parents,
- shorter stay in ICU and hospital
- and reduction in cost

Table 4. Reported Benefits of Early Extubation and/or Fast-Track Care

Reduced duration of mechanical ventilation with fewer ventilator-associated complications
Lower incidence of sepsis
Reduced requirements for inotropic support
Reduced requirements for sedatives with contributory reduction in associated hemodynamic compromise
Earlier start of enteral nutrition
More rapid patient mobilization
Earlier interaction with parents
Improved patient and parental satisfaction, reduced parental stress
Shorter ICU and hospital stays with associated cost reduction

Fast-Track care of higher risk pediatric patients

❖Anesthetic factors: Use of agents such as dexmedetomidine and remifentanil

❖Patients' factors associated with successful fast track care:

- Increase weight,
- older age,
- absence of trisomy 21,
- absence of preoperative pulmonary hypertension,
- lower requirement for inotropic support after surgery.

❖Surgery factors:

- Lower procedural complexity,
- shorter cardiopulmonary bypass and aortic cross clamping

Fast-Track care of higher risk pediatric patients

❖Factor associated with changing the plan :

- Low cardiac output,
- inadequate recovery from sedation,
- poor respiratory mechanics,
- sign of coagulopathy

❖Rate of reintubation following fast track:3% to 12%

❖Factors associated with reintubation:

- complexity of the procedure,
- need for reexploration,
- respiratory failure