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Factors that Correlate with the Decision to Delay Extubation Following Multi-Level Prone Spine Surgery

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Abstract

Background—Multi-level spinal decompressions and fusions often require long anesthetic and operative times which may result in airway edema and prolonged post-operative intubation. Delayed extubation can lead to broncho-pulmonary infections and other complications. This study analyzed which factors correlated with the decision to delay extubation after multilevel spine surgery.

Methods—We reviewed the records of 289 patients having multilevel spine surgery lasting 8 hours or more in the prone position from 2006 to 2012. Variables hypothesized to affect the decision of the anesthesiologist to delay extubation at the end of the surgery were collected. These included preoperative factors (age, gender, ASA Class, history of obstructive sleep apnea, BMI, **previous spine surgery, current cervical surgery**, anterior in addition to posterior spine surgery, emergency surgery), and intraoperative factors (difficult intubation, number of surgical levels, case time, estimated blood loss, fluid and blood administration, attending handoff and resident handoff, and case end time). We also compared the incidence of pulmonary post-operative complications between patients extubated at the end of the case to patients who had a delayed extubation.

Results—126 patients (44%) were kept intubated after multilevel spine surgery. Multiple linear regression analysis showed factors that correlated with prolonged intubation included age, ASA Class, procedure duration, extent of surgery, **total crystalloid volume administered**, total blood volume administered, and the case end time. Patients who had a delayed extubation had a threefold higher rate of post-operative pneumonia.

Conclusions—Our study finds that age, ASA class, procedure duration, extent of surgery, and **total crystalloid** and blood volume administered correlate with the decision to delay extubation in multilevel prone spine surgery. It also finds that the time that the case ends is an independent variable that correlates with the decision not to extubate at the end of a long multi-level spinal surgery. The incidence of post-operative pneumonia is higher in patients who had a delayed extubation after surgery.

Introduction

Multi-level spinal surgeries often require long anesthetic and operative times in the prone position. Large fluid shifts may result in facial and airway edema, precluding safe

extubation. Prolonged endotracheal intubation is not a benign process; it can lead to complications including glottic stenosis,(1) broncho-pulmonary infections,(2) and dysphagia.(3)

Predictors of delayed postoperative extubation have been studied in the cardiac, pediatric spine, and anterior spine surgery populations. Pre-operative factors including age(4), ASA Class, elevated body mass index (BMI)(5, 6), previous spine surgery(6) and baseline lung function(7) were shown to correlate with delayed post-operative extubation. Intra-operative factors associated with delayed postoperative extubation include duration of case(6), surgical levels(8), and volume of crystalloid and of blood transfusion.(6, 8, 9

In the current study, we reviewed multilevel spine surgeries done in the prone, or combination of supine and prone positions, lasting 8 hours or more. We collected patient information to identify pre- and intra-operative factors associated with the decision to delay extubation. In addition, we compared the post-operative pulmonary complications between the patients who were extubated at the end of surgery to those that had delayed extubation.

Materials & Methods

The study was performed with the approval from the Institutional Review Board (IRB) at Columbia University Medical Center. We retrospectively reviewed computerized anesthetic records, from January of 2006 to October of 2012 and identified 289 adult patients who underwent multi-level posterior or anterior/posterior spine surgery (decompressions and/or fusions at any vertebral level) lasting more than eight hours. Patients who were already intubated, had a tracheostomy prior to arrival to the operating room, and those who were kept intubated intentionally for planned surgery immediately after the first surgery, as part of a two part procedure, were excluded from the analysis.

Pre-operative and intraoperative patient information was retrospectively collected using computerized anesthetic records (CompuRecord, Philips Medical Systems; Andover, MA). Computer based hospital records (Webcis, Department of Biomedical Informatics, Columbia University Medical Informatics Services, NewYork-Presbyterian Healthcare, NY; Durham, NC and Eclipsys Sunrise Enterprise, Allscripts-Misys Healthcare Solutions, Inc; Nashville, TN) were used to follow the course of each patient post-operatively to determine extubation date, the number of hours after the end of surgery that extubation took place, post-operative pulmonary complications including reintubation, pneumonia, and fever.

Time of extubation was defined as the number of hours post anesthetic end time that the patient was extubated. Patients who were extubated at the end of a surgical case were defined to have an extubation time of zero hours. Delayed extubation was defined as the patient not being extubated at the end of the surgical case, prior to leaving the operating room.

Preoperative risk factors for delayed extubation included in the analysis were age, ASA classification, gender, body mass index (BMI), history of obstructive sleep apnea, history of previous spine surgery, **current** cervical surgery, **current anterior/posterior** spine surgery, **(involving both an anterior and posterior approach at any level)**, and **current** emergency surgery.

Intra-operative risk factors that were included were total case duration, extent of surgery (estimated by number of surgical levels), difficult intubation (planned fiberoptic intubation or unanticipated difficult intubation as described in the computerized anesthetic records), estimated blood loss, crystalloid volume administered, colloid volume administered, total

blood volume administered (sum of packed red blood cell volume and cell saver volume), attending anesthesiologist handover, resident anesthesiologist handover, and case end time.

Postoperative pulmonary complications that were included were re-intubation (intubation within 48 hours of extubation), pneumonia (clinical symptoms of hypoxia or dyspnea with CT findings of an infiltrate or consolidation and treated with antibiotics **during inpatient hospital course**), and fever (during inpatient hospital course).

Statistical analysis

Pre-operative and intra-operative variables were compared between the two study groups using nonparametric tests (Mann–Whitney *U* test for continuous variables, Fisher’s exact test for categorical variables). These variables were then tested for collinearity. Variance inflation factor (VIF) scores ranged from 1.2 to 3.9 (averaging 2.3), with a Condition Number of 4.7. VIF quantifies the multicollinearity and provides an index that measures how much the variance of an estimated regression coefficient is increased because of collinearity. The condition number measures how much the output value of the function can change for a small change in the input argument. Our calculated VIF scores suggest some collinearity between the independent variables, as would be expected; but with all VIFs much less than 10 and the condition number less than 15, enough independence between variables for a stable regression. Multivariate analyses were performed to identify factors independently associated with delayed extubation. All pre- and intra-operative variables significantly associated with the outcome ($P < 0.05$) by bivariate analysis were included in a multivariate logistic regression model. Model selection with multiple linear regressions was performed using a stepwise approach, adding those variables associated with the outcome ($p < 0.05$) in the order of decreasing explanatory power. Thus, variables were retained in the regression if their addition improved the adjusted R^2 value and if they reached a significance of 0.05. Interaction terms were not pursued. Using this model, predictors were considered to be significantly and independently associated with the outcome if they achieved a multivariate $p < 0.05$. Post-operative complications and incidence of re-intubation were compared between the two study groups using the 2 tailed Fisher’s exact test. The Bonferonni method was used to adjust for multiple comparisons. Analysis was performed using Excel (Microsoft Corp.; Redmond, WA) and JMP 7 software (SAS Institute Inc.; Cary, NC).

Results

289 patients were included in the analysis. 77 patients had cervical spine surgery as a component of their procedure, and 33 patients had anterior/posterior spine surgery. The anesthesiologist decided to delay extubation in 126 (44%) patients. All patients either received post-operative care in the neurosurgical Intensive Care Unit (NICU) or in the Post Anesthesia Care Unit (PACU) if a bed in the NICU was not available. Of the patients not extubated at the end of the case in the operating room, 4 were able to be extubated on postoperative day zero (day of surgery). Patients were generally extubated the following day, an average of 22 (\pm 18) hours after the surgery. (Figure 1)

Bivariate analysis identified eleven factors ($p < 0.05$) associated with the decision to delay extubation: age, ASA class, case duration, number of operative spinal levels, estimated blood loss, total crystalloid volume administered, total colloid volume administered, total blood volume administered, anesthesia attending handover, anesthesia resident handover, and case end time. Of these, age, ASA class, case duration, number of operative spinal levels, **total crystalloid volume administered**, total blood volume administered, and case end time remained significant in the multivariate analysis. (Table 1)

Post-operative pneumonia was more common (10.3%) in patients who were not extubated at the end of the case than those who were extubated at the end of the case (3.07%). This difference was significant using simple univariate analysis ($p=0.0146$) and remained significant after Bonferroni correction for three simultaneous comparisons ($\alpha = 0.0167$). Pneumonia was diagnosed in all cases by chest CT that was prompted by clinical symptoms including hypoxia, dyspnea, fever and cough. All patients were placed on antibiotic coverage after diagnosis. The mean time of pneumonia diagnosis was 2.83 days post procedure (SD 1.86). There was no significant difference in the rate of reintubation and the incidence of fever between patients extubated at the end of the case and patients who had delayed extubation. (Table 2)

Discussion

We present an observational, retrospective study that confirms that age, ASA class, case duration, number of surgical levels, **volume of crystalloid**, and total blood volume administered correlate with the decision to delay extubation in multilevel prone spine surgery, similar to cardiac and spine surgery literature(3–5, 7). Our study is the first to show that the time of day that the case ends is an independent factor that correlates with the decision not to extubate at the end of a multilevel spine surgery. In our study population, patients who had delayed extubation had a significantly higher incidence of pneumonia during their hospital admission. **Planning of the post-operative care, timing of multilevel spine surgery, and managing the expectations of the patient and family should take the relationship of age, ASA class, anticipated surgical duration, number of levels and blood loss into consideration.**

The relationship between the time of day a surgery takes place and morbidity or mortality has been investigated in different settings. Case start times after 4PM were associated with more adverse events than cases that started at 9AM in private and academic hospitals, even after controlling for patient and procedure characteristics.(10–12) In contrast, Sessler found no correlation between a composite complication score after general surgery and case start time by using the United States Agency for Healthcare Research and Quality's Clinical Classifications Software (AHRQ-CCS).(13)

Although morbidity has been shown in several studies to correlate with later case start time, there is no correlation between late start time and an increase in mortality in the Veteran's administration hospital setting in both the non cardiac,(11) and the cardiac population, when controlling for patient risk and urgency of the procedure.(14) No difference in mortality was found in an academic setting having non-emergent surgery with evening start times when controlling for patient factors.(13, 15) Transplant patients having evening surgery have the same mortality to those performed during daytime hours.(12, 16)

Prolonged intubation can be correlated with complications.(2, 3) However, it is unclear if the risks involved in leaving a patient intubated overnight when a case end time is very late are detrimental to the medical course of a patient, particularly after a prolonged surgery with large fluid shifts. At night, provider fatigue and decreased resource availability may affect outcome.(17) A higher mortality has been associated with cardiac arrest during the night, and discharge from an intensive care unit at night.(18–20) The potential difference in care at night may influence an anesthesiologist to decide to extubate a patient under more optimal conditions during daytime hours.

In addition, it is possible that patients who demonstrated impaired baseline respiratory status, or had showed impaired respiratory status at the end of the case may have to remain intubated. This peri-operative impairment of pulmonary status may be the actual factor that

correlates with developing pneumonia later in the post-operative period, and the decision to delay extubation may be a marker of that impairment.

Although the presence of attending handoff was not found to be an independent factor that correlates with delayed extubation at the end of a multilevel spine surgery, the presence of a handoff did correlate with delayed extubation in bivariate analysis. Part of the reluctance of an anesthesiologist to extubate an unfamiliar airway may play a factor in the decision to delay patient extubation. Further studies are needed to investigate the effect of the handoff on extubation.

This study has several limitations. Our study takes place in a single institution which is a large sized academic medical center that has a four year training program for anesthesiology residents; and thus reflects only one segment of anesthesia practice. The decision to extubate is a multifactorial decision on the part of the anesthesiologist and is not driven by a protocol. Further, delayed extubation may not be detrimental in our patient population. Many of the factors that correlate with extubation failure, reintubation after extubation, are the same factors that correlate with decision not to extubate at the end of multilevel spine surgery.(21) In our study population, the two patients who failed extubation within 48 hours were patients who had a delayed extubation in the ICU. The study involves patients after a specific surgery and the risks of extubation, such as airway compromise, must be weighed against the potential benefits, such as a decreased incidence of pneumonia. In addition, the study is not powered to look at other complications after surgery, including wound infection, cardiac morbidity, length of hospital stay and mortality.

In conclusion, the pre-operative factors that correlate with the decision to delayed extubation after multilevel spine surgery include age and ASA class. Intraoperative factors including case duration, number of surgical levels, total crystalloid volume administration, and total blood volume administered, correlate with the decision to delay extubation in multilevel prone spine surgery. Finally, case end time is an independent factor that correlates with delayed extubation in multilevel spine surgery. Post-operative pneumonia occurs at a higher rate in our study population in patients who had delayed extubation than those extubated at the end of the surgical case. **In formulating guidelines for safe extubations in clinical settings (22), the current practice of the anesthetic and surgical teams and their outcomes are important to analyze with the goal of the creation of a protocol.**

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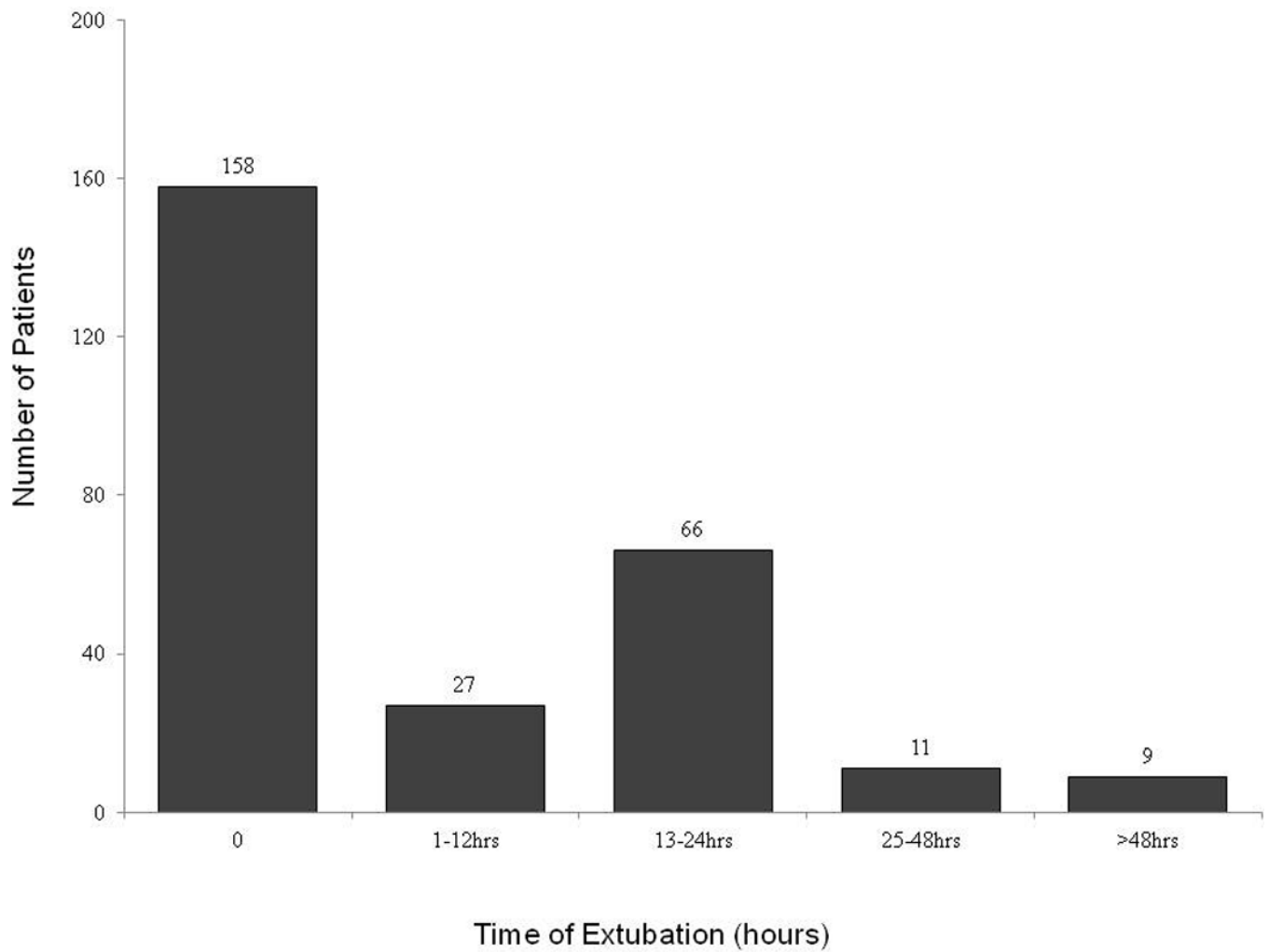


Figure 1.
Time is in number of hours after the conclusion of surgery. Extubated at time zero was defined as extubated intra-operatively at the conclusion of the surgery.

Table 1

Preoperative Factors	Extubation at end of case (n= 163)	Delayed extubation (n=126)	P Value Bivariate Model	P value Multivariate model
Age (years) Mean±SD	57 ± 16	62 ± 12	0.0164*	0.0204*
ASA (1/2/3/4)	(3/101/58/1)	(2/60/56/8)	0.0090*	0.0001*
Gender (% male)	84 (51%)	56 (44%)	0.2381	
BMI (kg/m ²) Mean±SD	26.7 ± 6.2	28.2 ± 8.0	0.0794	
Previous spine surgery (re-op)	54 (33%)	54 (43%)	0.1108	
OSA	8 (5%)	13 (10%)	0.1085	
Current Cervical spine surgery	50 (31%)	27 (21%)	0.0828	
Current Anterior (and posterior) surgery	21 (13%)	12 (10%)	0.4568	
Emergency surgery	3 (2%)	5 (4%)	0.3020	
Intraoperative Factors				
Difficult Intubation	50 (31%)	36 (29%)	0.7954	
Case Duration (mins) Mean±SD	550 ± 68	651 ± 110	<0.0001*	0.0124*
Spine Levels Mean±SD	5.8 ± 3	9 ± 5	<0.0001*	0.0211*
EBL (mL) Mean±SD	1059 ± 770	2068 ± 1466	<0.0001*	0.3533
Crystalloid Volume (mL) Mean±SD	4916 ± 1384	6281 ± 1982	<0.0001*	0.0199*
Colloid Volume (mL) Mean±SD	556 ± 481	909 ± 658	<0.0001*	0.7185
Blood Volume (mL) Mean±SD	364 ± 485	1183 ± 1192	<0.0001*	0.0266*
Anesthesia resident handoff	66 (40%)	79 (61%)	0.0006*	0.2817
Anesthesia attending handoff	64 (39%)	95 (74%)	<0.0001*	0.0968
Case end time (24 hr clock) ±SD (hr:min)	18:00 (2:04)	20:15 (2:44)	<0.0001*	0.0025*

Table 2

Postoperative Pulmonary Complications	Extubation at end of case (n= 163)	Delayed extubation (n=126)	P Value Fisher's Exact Test (2 tailed)
Reintubation	0 (0%)	2 (0.69%)	0.1892
Pneumonia	5 (3.07%)	13 (10.3%)	0.0140*
Fever	32 (19.63%)	32 (25.4%)	0.2558