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ORIGINAL ARTICLE

Risk factors for delayed extubation in thoracic and lumbar spine surgery: a retrospective analysis of 135 patients

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Abstract
Purpose Extubation may be delayed after spine surgery mainly for the concerns of airway safety. Risk factors for delayed extubation in cervical spine surgery have been described to include prolonged surgery time and amount of crystalloids or blood transfused. To date, risk factors for delayed extubation in thoracic or lumbar spine surgery have not been investigated. We retrospectively reviewed 135 consecutive patients from 2006 to 2009 who underwent thoracic or lumbar spine surgery by one particular surgeon to identify risk factors for delayed extubation.
Methods Data including patient factors, surgical time, anesthetic technique, blood loss, crystalloid and colloid administration, transfusion requirements, time to transfusion, and time to extubation were collected and analyzed. Delayed extubation was defined as the patient was not extubated in the operating room at completion of the surgery.
Results One hundred and eight patients were extubated in the OR. Delayed extubation occurred in 27 patients. Delayed extubation was significantly related to total operative time (6.6 ± 0.4 vs. 5.2 ± 0.1 h), volume of crystalloid replacement (6,018 ± 408 vs. 4,186 ± 130 cm^3), volume of total colloids infused (787 ± 93 vs. 442 ± 36 cm^3), intraoperative blood transfused (3.7 ± 0.5 vs. 0.7 ± 0.1 units); blood loss (2,137 ± 286 vs. 832 ± 50 cm^3), and time to starting blood transfusion (106 ± 12 vs. 199 ± 9 min).
Conclusions Our study suggests that intraoperative factors including prolonged surgical time, significant blood loss, larger volume of crystalloid and colloid infusion, and blood transfusion may be risk factors for delayed extubation following thoracic or lumbar spine surgery. Early blood transfusion may also increase the risk of delayed extubation. Patient factors did not affect extubation time.

Keywords Thoracic or lumbar spine surgery · Delayed extubation · Risk factors

Introduction

Spine surgery is a treatment choice for various spine diseases, including degenerative disc disease, myelopathy, stenosis, radiculopathy, fractures, and tumor. The number of thoracic or lumbar spine surgeries has been continuously increasing because of the aging population and improved imaging technologies, instrumentation, and surgical techniques. Decompressive procedures to release nerve roots and fusion procedures to stabilize the spine are commonly performed in thoracic or lumbar surgery. The patients are usually placed in prone position. Prolonged surgical time and potential blood loss may require a larger volume of fluid replacement, and even blood transfusion. These factors may lead to compromised airway safety (upper airway tissue swelling and edema), and disturbed metabolic status [1–3]. It is usually considered ideal to extubate the patient on the operating room table immediately at the completion of surgery, as this allows the surgeons to evaluate neurological function promptly. However, delayed extubation may sometimes be necessary for concerns of airway safety or hemodynamic stability.

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Tracheal extubation is a high-risk phase of anesthesia. The majority of problems that occur during emergence and extubation may be minor in nature, but a small and significant number may result in injury or death. The management of tracheal extubation has been discussed in detail [4]. Tracheal extubation is a vulnerable period for the patient; there is risk of aspiration, laryngospasm, cardiovascular instability, or hypoventilation. It has been shown that there are more adverse incidents associated with extubation than intubation and that these are occurring not only during extubation itself, but also during the time spent in the recovery room. A closed claims analysis of the American Society of Anesthesiologists database revealed that death or brain damage with induction of anesthesia decreased from 62 % of perioperative claims in 1985–1992 to 35 % in 1993–1999 [5]. This change may reflect widespread adoption of difficult airway guidelines that predominantly address induction of anesthesia. In contrast, the claims for death or brain damage associated with extubation and recovery remained almost the same [2].

Risk factors for delayed extubation in cervical spine surgery have been described as including prolonged surgery time, amount of crystalloids infused, or blood transfused [2, 3]. To date, risk factors for delayed extubation in thoracic or lumbar spine surgery have not been reported. The purpose of this retrospective study was to identify patient factors including age, gender, weight, height, comorbidities, and intraoperative factors including surgical time, blood loss, and resuscitation fluid (crystalloid, colloid, and blood) responsible for delayed extubation following thoracic or lumbar surgery. Multilevel thoracic or lumbar spine surgery is usually associated with significant intraoperative blood loss, often requiring blood transfusion. The effect of earlier blood transfusion from the time of incision on delayed extubation was also investigated.

Materials and methods

Data collection

The present study was approved by the Institutional Review Board. We retrospectively reviewed the consecutive cases of thoracic or lumbar spine surgery performed by one orthopedic surgeon at Upstate University Hospital from 2006 to 2009. A total of 172 patient charts were collected: 37 charts were excluded because of insufficient documentation, and 135 charts met the criteria and the data were collected and analyzed. Table 1 lists the patient factors including age, sex, height, and weight. Intraoperative factors are listed in Table 2, including surgical time, volume of crystalloid and colloid replacement, volume of blood loss, volume of blood transfusion, and time to transfusion. All patients had normal pulmonary function preoperatively.

Airway management protocol

A recommended guideline for the management of tracheal extubation in adult perioperative practice has been well described by the Difficult Airway Society (DAS) [4]. Airway and general risk factors were evaluated. The criteria for extubation include adequate respiratory function, cardiovascular stability, neurological/neuromuscular status, body temperature, and acid–base balance or electrolyte levels. The patients should be awake and responsive to verbal command. If these criteria were not met, extubation was delayed. In addition, if face swelling was noticed, an air leakage test was performed to assess the airway swelling and edema when the balloon was deflated. If there was minimal swelling and adequate air leakage, extubation was performed. Alternatively, if there was little to no air leakage, extubation was delayed. The decision for delayed extubation was explained and documented in the anesthesia records.

Surgical procedure

Surgery was limited to the thoracic and lumbar spine area. The major two categories of surgeries consisted of decompression and spinal fusion. Decompression surgery (discectomy and laminectomy) involved removing a small portion of the bone over the nerve root and/or disc material from under the nerve root to relieve pinching of the nerve and provide more room for the nerve to heal. Spinal fusion involved using a bone graft to stop motion at a painful vertebral segment, which in turn should decrease pain generated from the joint. The Gardner–Wells tongs with 15 pounds weight was used for head traction to keep the head in neutral position after the patient was placed in the prone position on a Jackson table.

Anesthesia

All patients received general anesthesia and were in prone position for the surgery after induction. Anesthesia was maintained with either total intravenous anesthesia (propofol and fentanyl infusion for thoracic spine surgery) or inhalational anesthesia (up to 1 MAC of volatile agent supplemented with intravenous propofol and fentanyl infusion as needed, for lumbar spine surgery). A second peripheral intravenous line was started in most of the patients after they had been anesthetized. In some patients at risk for hemodynamic instability or cardiac disease, an invasive radial arterial line was placed to monitor blood pressure continuously. Preinduction blood pressure was

Table 1 Characteristics of the study populations

	Delayed Extubation Group (n = 27)	Extubation Group (n = 108)	p
Age (years)	57.2 ± 1.4	53.1 ± 1.4	ns
Gender (female/male)	18/9	39/69	ns
Weight (kg)	82.4 ± 1.7	90.0 ± 1.9	ns
Height (cm)	161.8 ± 1.2	169.6 ± 1.3	ns
ASA grade (I/II/III)	0/16/12	2/74/32	0.57
Surgical spinal levels	5 to 6	3 to 4	ns

Data are presented as mean ± SE and analyzed by using unpaired Student's t test to test for statistical difference between groups. Data of ASA grade are presented as frequency table and analyzed by using the Wilcoxon rank-sum test for comparison analysis

Table 2 Intraoperative factors

	Delayed Extubation Group (n = 27)	Extubation Group (n = 108)	p
Surgical time (min)	399 ± 26	312 ± 7	<0.05
Total crystalloids (cm^3)	6,018 ± 468	4,186 ± 130	<0.05
Total colloids (cm^3)	787 ± 93	442 ± 36	<0.05
Estimated blood loss (cm^3)	2,133 ± 286	832 ± 50	<0.01
Blood transfused (units)	3.6 ± 0.5	0.7 ± 0.1	<0.01
Time to starting transfusion (min)	106 ± 12	199 ± 9	<0.05
Percent of patients transfused early	40.9	16.2	<0.05

Data are presented as mean ± SE and analyzed by using the unpaired Student's t test to test for statistical difference between groups

referred to as baseline pressure. The target blood pressure during the surgery was allowed 20 % deviation from baseline pressure. If there was a major change in neuromonitoring signals, either ephedrine or phenylephrine bolus was administered to increase the mean arterial pressure to 90 mmHg or more until the monitoring signals reverted to baseline. A major signal change is defined as 50 % decrease in amplitude or a 10 % increase in response latency as described in our previous study [6].

Hemoglobin transfusion triggers and targets

As pointed out by a recent study, target hemoglobin level for transfusion varies considerably among clinicians, even for similar procedures [7]. The decision to transfuse intraoperatively should take into account multiple physiological parameters, rather than an isolated laboratory measurement, thus making it difficult to standardize transfusion practice. Recent guidelines recommend hemoglobin transfusion triggers of 6–7 g/dl for general patients [8] and 7–10 g/dl for selected higher-risk patients [9]. In the present study, the hemoglobin level of 8–10 g/dl was considered a transfusion trigger based on the patient's medical condition.

Definition of delayed extubation

Patients were divided into extubated and Delayed Extubated Groups based on the time of extubation. The timing criteria are poorly defined in the literature. For the purposes of our study, we defined it as inability to extubate the patients within 20 min after the completion of the surgical procedure. These patients were extubated later in the post-anesthesia care unit (PACU) or in the intensive care unit (ICU).

Data analysis

All values are reported as mean ± standard error. ASA physical status data were analyzed by using the Wilcoxon rank-sum test, and all other data were analyzed by using an unpaired Student's t test to test for statistical difference between groups. Statistical significance was defined as a p value < 0.05.

Results

Patient characteristics

As shown in Table 1, the study population included 135 patients (69 men and 66 women) with a mean age of 54 years. One hundred and eight patients were extubated in the operating room at the completion of the surgery, identified as the Extubation Group. Twenty-seven patients were extubated at a later time either in ICU or PACU, identified as the Delayed Extubation Group. Reasons for delayed extubation for 16 patients were observable airway swelling and edema and for 2 patients were hemodynamic instability. In 9 patients, the reasons for the delayed extubation were not clearly documented.

Based on t test analysis, there were no significant differences in these two groups in weight, height, and age. ASA grade (I/II/III) was 0/16/12 for the Extubation Group patients and 2/74/32 for the Delayed Extubation patients ($p = 0.57$). The Delayed Extubation patients had more surgical spinal levels than extubation patients (5–6 levels vs. 3–4 levels).

Intraoperative factors

As shown in Table 2, the surgical time was significantly longer for the Delayed Extubation Group patients than for the Extubation Group patients, 399 ± 26 versus 312 ± 7 min ($p < 0.05$). The amount of crystalloids and colloids infusion was greater in the Delayed Extubation Group patients than in the Extubation Group patients: 6,018 ± 468 versus 4,186 ± 130 cm^3 ($p < 0.05$) for crystalloids and 787 ± 93 versus 442 ± 36 cm^3 ($p < 0.05$) for colloids. Estimated blood loss was greater in the Delayed Extubation Group than in the Extubation Group: 2,133 ± 286 versus 832 ± 50 cm^3 ($p < 0.05$). As a result, the Delayed Extubation Group patients received more packed red blood cell transfusion than the Extubation Group patients did: 3.6 ± 0.5 versus 0.66 ± 0.10 units ($p < 0.05$). The time to start blood transfusion was earlier in the Delayed Extubation Group than in the Extubation Group: 106 ± 12 versus. 199 ± 9 min ($p < 0.05$). The percentage of the patients receiving these early transfusions was also higher in the Delayed Extubation Group than in the Extubation Group, 40.9 % vs. 16.2 % ($p < 0.05$). Early transfusion was initiated when the anesthesiologist considered that blood loss was either rapid or ongoing for some time. Although such intraoperative management is difficult to quantitate, blood loss volume coupled with risk of intraoperative hemodynamic instability led to early transfusion.

Discussion

Tracheal extubation should be performed safely at the completion of a spine surgery for the surgeon to promptly evaluate the patient's neurological function. Under some circumstances, delayed extubation may be necessary for concerns of compromised airway or hemodynamic instability. Main findings of our retrospective study are that (1) as many as 20 % of patients who underwent thoracic or lumbar spine surgery had delayed extubation; (2) intraoperative factors including prolonged surgical time, larger volume of crystalloid and colloid infusion, and blood loss of more than 2,000 cm^3 may be risk factors for delayed extubation following thoracic or lumbar spine surgery.

Cata et al. [1] retrospectively reviewed 245 medical records of adult patients undergoing major lumbar spine surgery and found that approximate 25 % of patients had delayed extubation (the patients were later extubated in the PACU). In their study, there was no detailed description to explain the reason for delayed extubation. However, the rate of delayed extubation in our study is similar to their report. Tracheal extubation has been recognized to be a high-risk phase of anesthesia [4]. The majority of problems that occur during extubation and emergence are of a minor nature, but a small and significant number may result in injury or death. The extubation guideline has been recommended by the DAS [4]. Airway and general risk factors should be assessed before performing extubation. Airway factors include preexisting airway difficulties, perioperative airway deterioration, and restricted airway access. General factors include impaired respiratory function, cardiovascular instability, neurological/neuromuscular impairment, hypo/hyperthermia, and abnormalities of clotting, acid–base balance, or electrolyte levels. If any of these factors are identified, delayed extubation should be considered. Despite these recommendations for extubation criteria, it is a fairly subjective task for the anesthesiologist to determine the time for extubation. In the present study, delayed extubation was as high as 20 % in our patients. The determination of when to extubate was based on the individual anesthesiologist's clinical judgment, which reflected common clinical practice. The definition of delayed extubation in our study is very different from other studies of cervical spine surgery. In cervical spine surgery, delayed extubation was defined as 24 h after the completion of the surgery [2, 3]. In cervical spine surgery, potential causes of airway obstruction include pharyngeal edema, hematoma, cerebrospinal fluid leak, angioedema, and graft or plate dislodgment. The airway obstruction could last a prolonged time. Therefore, 24 h observation might be needed for edema and swelling to subside for safe extubation. In our study, possible airway swelling and edema were usually caused by prone positioning and/or fluid administration. Therefore, the swelling or edema of airway may be not so severe as in cervical spine surgery and may subside more rapidly, so extubation may be performed several hours after the completion of thoracic or lumbar spine surgery.

Airway obstruction is a major reason for delayed extubation in cervical spine surgery. Sagi et al. [10] retrospectively reviewed 311 anterior cervical procedures. They found that 19 patients (6.1 %) had an airway complication and 6 (1.9 %) required reintubation. One patient died. All complications except for two were attributable to pharyngeal edema. Kwon et al. [3] retrospectively analyzed the postoperative course of 24 patients who had undergone single-stage, multilevel anterior cervical corpectomy and posterior cervical fusion. Postoperatively, a leak test was performed for all patients that involved deflating the cuff of the endotracheal tube, occluding the lumen of the tube, and asking the patient to breathe around the deflated cuff. On the basis of the patient's ability to move air during inspiration and expiration around the occluded endotracheal tube and the absence of respiratory distress (tachypnea, hypercarbia or acidosis, and hypoxia), the attending staff made a decision to extubate the patient. In their study, 11

patients were extubated on the first postoperative day, and 11 were extubated beyond day 1. They found that patient factors including age, weight, smoking, medical comorbidities, and American Society of Anesthesiologist (ASA) class were not significantly related to delayed extubation. Our study provides new evidence that patient factors are also not significantly related to delayed extubation in thoracic or lumbar spine surgery. They identified that intraoperative factors including surgery that involved more than three vertebral bodies, a blood loss >300 cm^3, and an operative time >5 h were significantly associated with delayed extubation. In our study, intraoperative factors including blood loss >2,000 cm^3, operative time >6.5 h, crystalloids more than 6,000 cm^3, blood transfusion of more than 3 units, and earlier transfusion are significantly associated with delayed extubation. Our findings are in agreement with these studies suggesting that surgical time, crystalloid volume, colloid volume, and blood loss and replacement rather than patient characteristics are risk factors for delayed extubation.

Patients are usually placed in the prone position for thoracic or lumbar spine surgery. As Edgcombe et al. [11] recently reviewed, the prone position causes many physiological changes and is associated with many complications. Upper airway obstruction from macroglossia and oropharyngeal swelling has been reported after surgery in the prone position [12]. Supraglottic swelling and edema can cause posterior displacement of the epiglottis and inspiratory obstruction. Glottic, subglottic, and tracheal edema can cause life-threatening airway compromise. Prolonged surgical time and a larger quantity of fluid resuscitation or blood transfusion may exacerbate upper airway compromise. Our study also showed that early transfusion may increase the risk of delayed extubation. The decision for earlier blood transfusion was made based on clinical judgment. Early transfusion usually reflects a more traumatic and extensive procedure and predicts more blood loss and therefore a greater blood transfusion may be required. The present study suggests that not only the quantity of the blood transfusion but also the time to start the transfusion may affect the time to extubate following thoracic and lumbar spine surgery.

One limitation in our study is the small number of cases. A large population study is needed to further define the risk factors in thoracic or lumbar spinal surgery. Another limitation is that in the present study there were no patients with intubation difficulties; all patients were intubated with a regular laryngoscope or glidescope after intravenous induction. However, in practice, anesthesiologists may face the challenge of extubating a patient with difficult intubation. If a difficult intubation was encountered, an abundance of caution and planning should be exercised at extubation time. and one such extubation algorithm as presented by the DAS [4] could be followed. The key decision to be made is whether it is safer to extubate, or preferable for the patient's trachea to remain intubated until safer and more favorable conditions are present. If it is considered safe to extubate, then an awake extubation should be performed. As pointed by Heidegger, no single technique covers all clinical scenarios and no technique is without risk. The ultimate decision whether to remove the tracheal tube or supraglottic airway device or to postpone the procedure is primarily based on experience [13]. The third limitation is that documentation in some delayed extubation patients (9/27) was poor. However, it is understandable that these patients might not meet the criteria for extubation in the operating room. We speculate that the airway safety concern may be a main reason for the delayed extubation in these patients.

In summary, patient factors such as age, height, weight, or gender were not significantly related to delayed extubation in thoracic and lumbar spine surgery. Intraoperative factors including surgical time, crystalloid volume, colloid volume, and blood loss and replacement contribute to delayed extubation.

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