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Emergence from Anesthesia in the Prone versus *Supine Position in Patients Undergoing Lumbar Surgery*

Michael A. Olympio, M.D., B. Lee Youngblood, M.D.,† Robert L. James, M.S.‡*

Background: **Conventional supine emergence in patients undergoing prone lumbar surgery frequently results in tachycardia, hypertension, coughing, and loss of monitoring as the patient is rolled supine. The prone position might facilitate a smoother emergence because the patient is not disturbed. No data describe this technique.**

Methods: **Fifty patients were anesthetized with fentanyl, nitrous oxide, isoflurane, and rocuronium. By the conclusion of surgery, all patients achieved spontaneous ventilation and full reversal of neuromuscular blockade in the prone position, as the volatile anesthetic level was reduced. Baseline heart rate and mean arterial pressure were recorded. Patients were then randomized at time 0 to the supine (n = 24) or prone (n = 21) position as 100% oxygen was administered. Patients in the supine position were then rolled over, while those in the prone position remained undisturbed. Heart rate, mean arterial pressure, and coughs were recorded until extubation. Tracheas were extubated on eye opening or purposeful behavior.**

Results: **When compared with the supine group, prone patients had significantly less increase in heart rate ($P = 0.0003$, maximum increase 9.3 *vs.* 25 beats/min), less increase in mean arterial pressure ($P = 0.0063$, maximum increase 4.8 *vs.* 19 mmHg), less coughing ($P = 0.0004$, 7.0 *vs.* 23 coughs), and fewer monitor disconnections ($P < 0.0001$). Time to extubation from time 0 was similar (4.0 *vs.* 3.7 min, prone *vs.* supine). No one required airway rescue. There was no significant difference in need for restraint (three prone, four supine).**

Conclusions: **Prone emergence and extubation is associated with less hemodynamic stimulation, less coughing, and less disruption of monitors, without specifically observed adverse effects, when compared with conventional supine techniques. (Key words: Airway; coughing; extubation; hypertension; safety; unconventional.)**

CONVENTIONAL supine emergence of patients undergoing prone lumbar surgery is frequently associated with tachycardia, hypertension, coughing, and loss of monitoring as patients are rolled into the supine position. The causes of the tachycardia and hypertension are multifactorial,[1] although we believe that tracheal irritation is the predominant cause. Irritation from the endotracheal tube is increased as the head is lifted or turned, and this irritation can be associated with a significant amount of coughing.

Multiple clinical investigations have documented the hyperdynamic response to emergence and extubation, focusing on tracheal irritation as the cause.[1–4] These studies have demonstrated that intravenous or intratracheal administration of lidocaine is partially effective in suppressing this response. However, Gonzalez *et al.*[5] verified that time to emergence is delayed with intravenous lidocaine and that coughing may not be suppressed if patients are allowed to awaken before removal of the tube. As Gonzalez *et al.* point out, the plasma lidocaine level required to effectively suppress coughing in humans[5] is three times the level that decreases halothane minimum alveolar concentration by 40% in animals.[6] Thus, we sought to find a better technique of emergence, without lidocaine, by avoiding the movement that causes tracheal irritation and awakening our patients in the prone position.

We therefore hypothesized that complete, undisturbed emergence and extubation in the prone position, compared with the supine position, would be associated with greater hemodynamic stability during the emergence, less coughing, and the uninterrupted continuation of all monitoring devices. Avoidance of adverse events, particularly involving the airway, or movement off the operating table, would be critical in this previously undescribed procedure.

Materials and Methods

The Institutional Review Board of Wake Forest University School of Medicine approved this study. After obtaining informed consent, we sequentially enrolled patients (American Society of Anesthesiologists class I, II, and III; age > 18 yr) scheduled for prone lumbar laminectomy surgery. We excluded those with difficult airways, obesity (body mass index > 35 kg/m^2), or symptomatic reflux, but not smokers or those with reactive airways. Patients knew that they would be randomized to the supine or prone position during emergence and were told to listen for verbal commands as they awakened. Glycopyrrolate (0.2 mg) was given intravenously, and patients were induced with thiopental and then anesthetized with fentanyl (4–8 μg/kg), isoflurane (minimum 0.2% end tidal), and nitrous oxide (70% in oxygen) with rocuronium. Anesthetists were instructed to administer the fentanyl early in the case. No intravenous or intratracheal lidocaine was allowed. All patients had oral esophageal stethoscopes inserted, and it was common

* Associate Professor, † Resident, ‡ Bio-Statistician.

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Address reprint requests to Dr. Olympio: Department of Anesthesiology, Wake Forest University School of Medicine, Medical Center Boulevard, Winston-Salem, North Carolina 27127-1009. Address electronic mail to: molympio@wfubmc.edu. Individual article reprints may be purchased through the Journal Web site, www.anesthesiology.org.

practice to place oral gastric tubes. Patients were then rolled prone onto a level, standard operating table, lying on a pair of axial chest rolls. The head was turned approximately 45° to the side and supported by a curved foam head cradle. The endotracheal tube and stethoscope were taped only to the upper, lateral edge of the mouth. Eye lubrication was applied, but the eyes were not taped. In this manner, the upper eye, half of the face, and tubes were readily visible and accessible during emergence.

During the study we became aware of the surgeons' sporadic, preoperative, subcutaneous infiltration of 0.25% bupivacaine. We were unaware of this practice when the study was initiated. Retrospective data on the use of local anesthetic was collected.

Anesthesia teams were not preselected or controlled. They were given general guidelines to conduct the anesthetic and were specifically told to use their clinical judgment in preventing movement during closure. The anesthetist had to achieve the following conditions: (1) spontaneous ventilation, (2) complete reversal of neuromuscular blockade, and (3) minimization of isoflurane to a suggested minimum level of 0.2% end-tidal concentration, with continuation of 70% nitrous oxide in oxygen. After the surgery was completed and the drapes were removed, three sets of baseline data were recorded over 2 min (T−2, T−1, and T0). All data were collected by either of the first two authors. Operating room personnel were instructed to secure the stretcher beside the operating table and to surround the patient. Patients were randomized at T0 to either the supine or prone position. The anesthesia team was instructed to attempt to retain all monitoring attachments in all patients. At T0, isoflurane and nitrous oxide were discontinued and replaced by 100% oxygen. The experimental treatment was then immediately initiated.

Supine patients were rolled supine, whereas prone patients remained undisturbed. Heart rate (HR) and mean arterial pressure (MAP) were recorded each minute (T1, T2, T3, and so on until extubation). Coughs, disconnections, and minutes to extubation from T0 were counted. Patients were not stimulated in any other manner until they began to move spontaneously. At that point, the anesthetist was only allowed to call their name or give a simple verbal command to open their eyes, without speaking loudly or physically stimulating the patient. Prone patients were not suctioned. Supine patients could not be suctioned until immediately before extubation. At the discretion of the attending anesthesiologist, patients were extubated when responsive or purposeful, and monitoring was continued for variable lengths of time. Monitors were then disconnected, prone patients were then rolled supine, and all patients exited the operating room. The frequency of patient restraint during emergence, airway rescue after extubation, and sore throat on discharge from the postanesthesia care unit were recorded, in addition to demographic data.

Statistical Analysis

Continuous patient demographic parameters, HR, and MAP were compared between treatment groups at baseline using the *t* test with Satterthwaite adjustments for unequal variance when appropriate. Anesthesia time, surgical time, estimated blood loss, and crystalloid replacement were log normal in distribution, and thus required log transformation before *t* testing. Treatment group differences in fentanyl dosage were compared using the Wilcoxon rank sum test. Differences between

Table 1. Demographics by Group

Demographic	Supine (n = 24)	Prone (n = 21)
Age (mean yr ± SD)	52 ± 16	45 ± 14
Gender (M/F)	15/9	8/13
ASA Class		
I	6	8
II	16	12
III	2	1
Body mass index (mean kg/m^2 ± SD)	27.0 ± 0.67	27.2 ± 1.1
Cigarette use (frequency)	7	10
β-blocker (frequency)	9	8
Fentanyl dosage (median μg/kg) (range)	5.0 (4.0–7.3)	5.4 (4.0–8.0)
Baseline HR (mean beats/min ± SD)	75 ± 14	80 ± 14
Baseline MAP (mean mmHg ± SD)	94 ± 14	96 ± 13
Surgical infiltration of 0.25% bupivacaine (frequency) (mean ml ± SD)	6 28.3 ± 4.1	12* 20.9 ± 8.3
Anesthesia time (min) (geometric mean with 95% confidence interval)	144 (130–160)	170 (143–201)
Surgical time (min) (geometric mean with 95% confidence interval)	99 (86–114)	123 (99–153)
Estimated blood loss (ml) (geometric mean with 95% confidence interval)	121 (83–177)	123 (99–153)
Crystalloid replacement (ml) (geometric mean with 95% confidence interval)	1,412 (1,229–1,621)	1,540 (1,158–2,048)

* *P* = 0.0012 compared with supine by exact chi square test.

ASA = American Society of Anesthesiologists; HR = heart rate; MAP = mean arterial pressure.

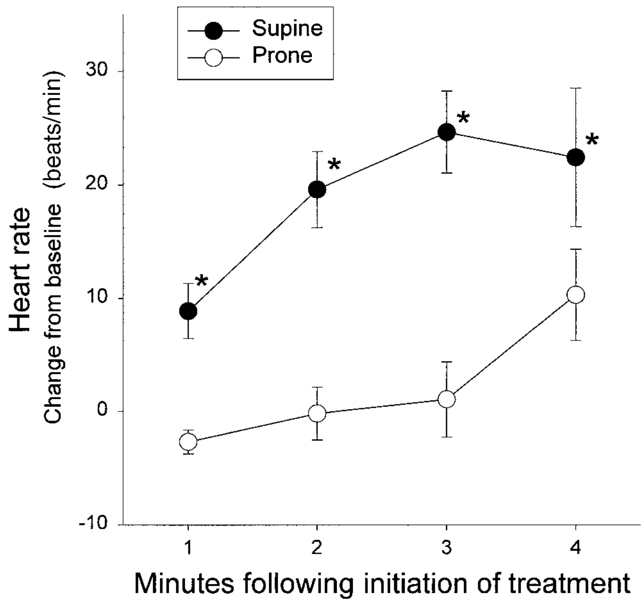

Fig. 1. Mean change in heart rate from baseline (± SE) at each minute after the initiation of treatment. Asterisks indicate significant increases in heart rate in supine compared with prone patients. This figure includes data for 33 patients who were extubated before the 5-min mark. Subsequent intervals could not be statistically compared because of inadequate numbers of patients.

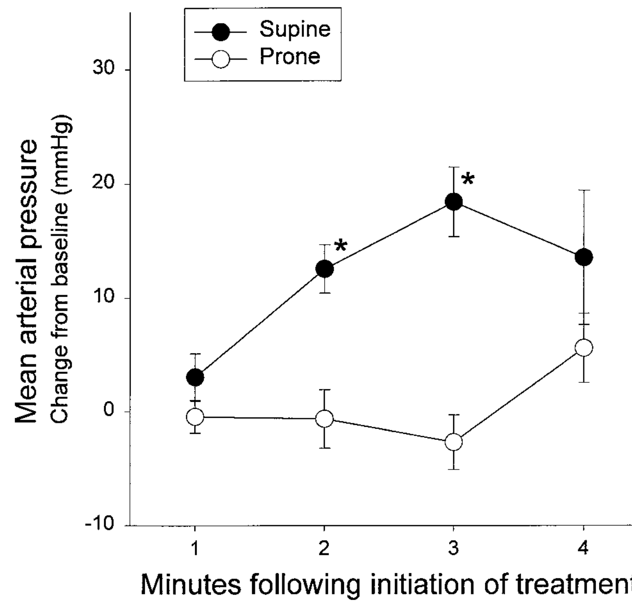

Fig. 2. Mean change in mean arterial pressure (± SE) at each minute after the initiation of treatment. Pressure increased significantly in the supine compared with prone patients at T2 and T3 and also approached significance at T4. This figure includes data for 33 patients who were extubated before the 5-min mark. Subsequent intervals could not be statistically compared because of inadequate numbers of patients.

dichotomous parameters (disconnections, restraint, sore throat, gender, cigarette use, β-blockade, and surgical infiltration of local anesthetic) were compared using the exact chi-square test. Demographic and baseline data were summarized as mean values ± SD (normal distributed data), geometric means with their 95% confidence intervals (log-normal data), medians and range (discrete data), and frequencies (dichotomous parameters).

Treatment effects on changes in HR and MAP from baseline were tested for significance over time using mixed effects repeated-measures analyses. The repeated-measures analyses included those covariates that could effect changes in HR and MAP: anesthesia time, fentanyl use, surgical infiltration of local anesthetic, β-blocker use, estimated blood loss, crystalloid replacement, baseline HR, and MAP. These covariates were used to adjust for any group differences in HR and MAP. To address the concern that the use of local anesthetic might affect blood pressure and heart rate, interaction between the use of local anesthetic and treatment were also included in the repeated-measures analyses. Bonferroni corrections were made for *post hoc* comparisons after the repeated-measures analyses only when the overall effects were not significant.

Similarly, extubation times between the treatment groups were compared using analysis of variance with covariate adjustments for anesthesia time, fentanyl use, and surgical infiltration of local anesthetic. Treatment differences in patient cough frequency were compared using the Wilcoxon rank sum test. P values < 0.05 were considered significant. All statistical analyses were performed using SAS version 8.0 (SAS Institute, Inc., Cary, NC).

Results

Fifty patients were entered into the study. One supine patient and four prone patients were eliminated for protocol violations (one coughed before T0, isoflurane was not reduced in another, and three did not receive the minimum 4 μg/kg of fentanyl). Thus, 24 supine and

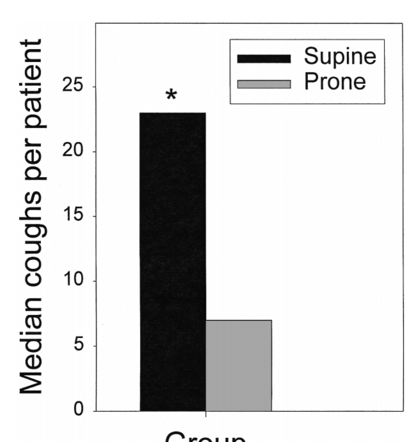

Fig. 3. The bar graph demonstrates dramatically higher coughing in the supine group when compared with prone patients. A cough was specifically defined as a forced exhalation. Unbiased observers within the operating room counted these coughs, although they were obviously not blinded to treatment group. The counting ended immediately on extubation.

Table 2. Number of Patients by Group Having the Observed Number of Disconnects

Disconnects	Supine (n = 24)	Prone (n = 21)
0	0	19
1	4	1
2	6	0
3	7	0
4	4	1
5	2	0
6	1	0

$P < 0.0001$.

Prone *vs.* supine by exact chi square testing.

21 prone patients were compared. There were no statistically significant differences in demographics between groups except for the surgical subcutaneous infiltration of 0.25% bupivacaine at the beginning of the case ($P = 0.037$, table 1). The mean dose was 28.3 ± 4.1 ml for 6 supine patients and 20.9 ± 8.2 ml in 12 prone patients. Only four patients required a second direct laryngoscopy, and no intubation was described as difficult.

Thirty-three of 45 patients were extubated before the 5-min mark after initiating treatment and are represented in figures 1 and 2. These include 18 of 24 supine and 15 of 21 prone patients. Data analysis was limited to the first 4 min because there were inadequate numbers to statistically compare patients still remaining asleep after 4 min. There was no difference in frequency between supine and prone patients remaining intubated at each of the times T5–T7.

Prone patients had significantly less increase in HR above baseline at all intervals—T1, T2, T3, and T4 (fig. 1, $P = 0.0003$)—and significantly less increase in MAP at intervals T2 and T3 (fig. 2, $P = 0.0063$) compared with supine patients. The maximum increase in HR was 9.3 ± 3.7 beats/min for prone patients *versus* 25 ± 2.9 for supine patients. The maximum increase in MAP was 4.8 ± 2.9 mmHg for prone patients *versus* 19 ± 2.5 for supine patients. Prone patients also had significantly fewer coughs (fig. 3, $P = 0.0004$) and fewer disconnections (table 2, $P < 0.0001$).

Results of repeated-measures analyses for HR and MAP

Table 3. Results of Repeated Measures Analysis on Heart Rate Change from Baseline

Source	*P* Value
Baseline heart rate	0.0772
Treatment	0.0003
Time	0.0001
Interaction of time and treatment	0.0494
Anesthesia time (log)	0.8606
Fentanyl	0.9796
Local anesthetic	0.4164
Interaction of local anesthetic and treatment	0.3893
β-blocker	0.0098
Estimated blood loss (log)	0.9341
Crystalloid replacement (log)	0.8026

Table 4. Results of Repeated Measures Analysis on Mean Arterial Pressure Change from Baseline

Source	*P* Value
Mean arterial pressure	0.0103
Treatment	0.0063
Time	0.0003
Interaction of time and treatment	0.0008
Anesthesia time (log)	0.8346
Fentanyl	0.1641
Local anesthetic	0.2988
Interaction of local anesthetic and treatment	0.0985
β-blocker	0.9308
Estimated blood loss (log)	0.1910
Crystalloid replacement (log)	0.9064

are listed in tables 3 and 4. Neither local anesthetic nor its interaction with treatment was found to have significant effects on HR. The effect of adding the local treatment interaction to the repeated-measure analysis on MAP, although not significant, had a P value of 0.0985, suggesting the possibility that local anesthetic does influence HR in the prone and supine treatments differently. Thus, to further address the concern that local anesthetic may be causing the observed differences in MAP between the treatment groups, a repeated-measures analysis was performed on the subgroup of just those patients who received no local anesthetics. The subgroup analysis found the same comparisons between the prone and supine treatments statistically significant as in the full data analysis. Thus, the treatment group differences between the prone and supine treatments with respect to MAP and HR does not appear to be a result of the use of local anesthetics.

Other outcome variables are listed in table 5. Extubation times and the incidence of airway rescue, patient restraint, and sore throat did not differ between groups. None of the 45 patients required airway rescue. No patient vomited in either group.

Discussion

This study demonstrates that the prone position for emergence and extubation was superior to the supine position in carefully selected patients, following these specific experimental conditions. We realize that inade-

Table 5. Outcomes by Group

Outcome	Supine (n = 24)	Prone (n = 21)
Extubation time (min) (geometric mean with 95% confidence interval)	3.7 (3.1–4.5)	4.0 (3.4–4.7)
Airway rescue (frequency)	0	0
Patient restraint (frequency)	4	3
Sore throat (frequency)	5	6

There were no significant differences between the supine and prone groups.

quate numbers of patients have been studied to presume the safety of this technique. Prone emergence and extubation has not been described or advocated in standard textbooks of anesthesia, nor in the literature as determined by Medline search. Concern for the airway is paramount in this procedure, and we made considerable efforts to ensure patient safety during this unconventional technique. We eliminated patients with difficult airways and achieved regular, spontaneous ventilation with complete reversal of neuromuscular blockade while patients were still adequately anesthetized. In that manner, a greater degree of airway safety was assured, as the anesthetic was further reduced. That no airway rescue was required in either group also suggests that laryngeal edema from the prone position was not a significant factor in these laminectomy patients. Extubation during stage II of anesthesia could have increased the risk of laryngospasm; this was avoided by not disturbing the patients during emergence. To further ensure safety, the operating-room team had to surround the patient, with stretcher aside, during the entire emergence phase. Finally, this study was designed to improve safety by retaining all monitoring devices uninterrupted throughout emergence.

We believe that the reduction in hemodynamic stimulation was a direct result of not disturbing the patients' tracheas. Avoiding oropharyngeal suctioning, head turning, esophageal stethoscope removal, and bodily movement all serve to reduce tracheal irritation from the endotracheal tube. Alternatively, if suctioning the prone patient was desired, it could be accomplished similarly to the supine patient, using a second pair of hands immediately before extubation. In our experience, however, this was unnecessary.

We specifically chose a narcotic-based technique to reduce coughing in all patients and did not dictate or suggest anything about fentanyl for cough suppression at the end of the case. Because both groups received equal doses of fentanyl, we presume the antitussive effects were similar in both groups.

In retrospect, these results could have been strengthened if there was no use, or equivalent use, of infiltrated local anesthetic among groups. Regardless, extensive statistical analyses consistently showed a highly significant effect of the prone position itself. Perhaps additional studies are warranted to evaluate the effects of local anesthetic infiltration on hemodynamic variables during supine emergence.

The history of smoking, dosage of fentanyl, or use of pharmacologic β blockade would be expected to affect the degree of cough and hemodynamic response; however, these frequencies were similar between groups. Both groups of patients also had similar degrees of blood loss and fluid administration, two additional variables that might affect HR and MAP.

Prone emergence was nearly always observed to be a calm and smooth transition from surgery to the awake, extubated state. Alternatively, supine patients could remain more deeply anesthetized or paralyzed until after the rollover, and then undergo a similar procedure for emergence. Certainly, this would add significant time to operating room turnover. Intravenous lidocaine might not be effective in suppressing hemodynamic changes, because studies that have documented its suppressant effects have not carefully controlled for head movement.[1–4]

Patients in the supine group did not develop hypertension and tachycardia until they were actually turned, and by then it was difficult to treat the problem. Monitors were disrupted and had to be reconnected immediately, and the anesthetist was immediately preoccupied with extubation. One might then require prophylactic suppression of tachycardia and hypertension if these responses are a particular risk to the patient.

We were concerned that patients in either group could become disoriented and require restraint. The prone position did not increase the incidence of this problem. Thus, in any position, patients must be observed and protected against uncontrolled movement. Of note, only 1 of 45 patients moved during closure, despite complete reversal of neuromuscular blockade, spontaneous ventilation, and decreasing anesthetic depth.

In conclusion, our data suggest that prone emergence and extubation should be considered as an alternative approach to conventional awakening in carefully selected patients. It clearly offers the advantages of hemodynamic stability, less coughing, continuation of monitoring, and especially the convenience of an undisturbed awakening. This technique might further be applicable to patients at risk for myocardial ischemia or stroke, or when surgical concerns dictate that coughing and hypertension be avoided.

References

1. Bruder N, Ravussin P: Recovery from anesthesia and postoperative extubation of neurosurgical patients: A review. J Neurosurg Anesth 1999; 11:282–93

2. Bidwai AV, Bidwai VA, Rogers CR, Stanley TH: Blood-pressure and pulse-rate responses to endotracheal extubation with and without prior injection of lidocaine. ANESTHESIOLOGY 1979; 51:171–3

3. Gonzalez RM, Bjerke RJ, Drobycki T, Stapelfeldt WH, Green JM, Janowitz MJ, Clark M: Prevention of endotracheal tube-induced coughing during emergence from general anesthesia. Anesth Analg 1994; 79:792–5

4. Leech P, Barker J, Fitch W: Proceedings: Changes in intracranial pressure and systemic arterial pressure during the termination of anaesthesia. Br J Anaesth 1974; 46:315–6

5. Yukioka H, Yoshimoto N, Nishimura K, Fujimori M: Intravenous lidocaine as a suppressant of coughing during tracheal intubation. Anesth Analg 1985; 64:1189–92

6. DiFazio CA, Neiderlehner J, Burney RG: The anesthetic potency of lidocaine in the rat. Anesth Analg 1976; 55:818–21