A preliminary study of volatile agents or total intravenous anesthesia for neurophysiological monitoring during posterior spinal fusion in adolescents with idiopathic scoliosis

Running title: TIVA versus volatile anesthesia

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Abstract

Study Design. A prospective randomized controlled trial.

Objective. The purpose of this study was to prospectively compare the efficacy of neurophysiologic monitoring during general anesthesia with either a total intravenous technique or with the volatile anesthetic agent, desflurane.

Summary of background data. A total intravenous anesthetic technique is generally chosen when neurophysiological monitoring is used as it has been shown to facilitate such monitoring. Despite this,
with prolonged infusions of propofol, prolonged awakening times may be seen which may impact the
time required for postoperative neurological assessment or more importantly result in significant delays
should a wake-up test become necessary. To date, there are no prospective trials comparing intravenous
techniques with a volatile-based anesthetic technique and its effects on neurophysiological monitoring.

Methods. This prospective study compares somatosensory evoked potential and motor evoked potential
monitoring during posterior spinal fusion in 30 adolescents. The patients were randomized to receive a
total intravenous technique with propofol-remifentanil or a volatile agent based technique with
desflurane-remifentanil.

Results. The groups were similar in regards to age, weight, height, body mass index, Cobb angle, and
distribution of Lenke classifications. No differences were noted in anesthesia time, surgery time,
inhaeraoperative fluids, or estimated blood loss between the two groups. Time to eye opening, time to
following commands, and time to tracheal extubation were shorter in the volatile anesthesia group when
compared to the TIVA group. No clinically significant difference was noted in the amplitude or latency
of SSEP monitoring. Although statistically significantly greater voltage amplitude was required to
generate a MEP, the voltage amount was within a clinically acceptable range.

Conclusion. Our data demonstrate that a volatile-based anesthetic regimen is feasible even during
neurophysiological monitoring. Advantages include a more rapid awakening and the feasibility of a
rapid wake-up test (less than 5 minutes) in the event that irreversible changes in neurophysiological
monitoring are noted.

Key Words: Pediatric anesthesia, adolescent scoliosis, anesthesia, motor-evoked potentials,
amplitude, latency, somatosensory evoked potentials, pain scores, opiate consumption, posterior
spinal fusion, total intravenous anesthesia, desflurane, volatile anesthesia, remifentanil
Mini-abstract. A prospective study comparing somatosensory evoked potential and motor evoked potential monitoring was conducted during posterior spinal fusion in 30 adolescents. The patients were randomized to receive a total intravenous technique with propofol-remifentanil or a volatile agent based technique with desflurane-remifentanil.

Key points.

1. A volatile-based anesthetic regimen is feasible even during neurophysiological monitoring.
2. No clinically significant difference was noted in the amplitude or latency of SSEP monitoring.
3. Although a higher voltage amplitude was required to generate a MEP, the voltage amount was within a clinically acceptable range.
4. Advantages of a volatile agent based include a more rapid awakening and the feasibility of a rapid wake-up test

Introduction

Posterior spinal fusion (PSF) remains the primary surgical intervention for the correction of adolescent idiopathic scoliosis. The potential for inadvertent spinal cord injury and the resultant neurological deficits are recognized complications of the procedures. To decrease the incidence of such problems, various methods have been used to identify spinal cord injury including intraoperative neurophysiological monitoring with somatosensory (SSEP) and motor evoked potentials (MEP), an intraoperative wake-up test, or the demonstration of ankle clonus.1-4 Given concerns with the latter two tests, neurophysiological monitoring is generally accepted as the current standard of care. Without electrophysiological monitoring, the incidence of neurologic deficits following surgical procedures on the vertebral column may be as high as 3.7-6.9%.5 This can be decreased to less than 1% with appropriate monitoring.5 The American Academy of Neurology in their guidelines on intraoperative monitoring concluded that the evidence favors the use of monitoring as a safe and efficacious tool in
clinical situations where this is a significant nervous system risk, provided its limitations are appreciated. However, when neurophysiologic monitoring techniques are used, the anesthetic technique must be modified to facilitate monitoring.

In general, a total intravenous anesthesia (TIVA) technique with propofol and an opioid is frequently chosen to optimize intraoperative neurophysiological monitoring.\(^6\,^7\) Despite its efficacy, dose-related adverse effects may occur with propofol including prolonged awakening times, lipidemia, alteration of platelet function, and the development of a metabolic acidosis.\(^8\,^9\,^{11}\) The prolonged awakening times at the completion of the case can generally be addressed proactively by an early discontinuation of the infusion. However, intraoperatively, if changes are noted during neurophysiologic monitoring, a wake-up test may be necessary. At that time, awakening times from propofol may be prolonged related to its context sensitive half-life which is prolonged depending the duration of the infusion.

Although the newer volatile agents including desflurane provide a rapid awakening even after prolonged administration, when used in concentrations greater than 0.5 MAC (mean alveolar concentration), it has been suggested that these agents may significantly affect neurophysiological monitoring.\(^12\) Given these concerns, TIVA is a frequently chosen technique to provide anesthesia during PSF. However, our clinical practice and experience demonstrates that we can achieve successful monitoring of both MEP’s and SSEP’s with the titrated administration of the volatile anesthetic agent, desflurane. In our practice, desflurane in concentrations of 0.6-0.8 MAC can be administered to ensure amnesia while allowing for effective neurophysiological monitoring. To date, there are no prospective trials comparing TIVA with a volatile-based anesthetic technique and its effects on neurophysiological monitoring. The current study prospectively compares the efficacy of neurophysiologic monitoring during general anesthesia with either TIVA or the volatile anesthetic agent, desflurane.
Materials and Methods

Following IRB approval and written informed consent from a parent and assent from the patient, the patients were randomized to receive general anesthesia with either TIVA (propofol-remifentanil) or a volatile agent (desflurane-remifentanil) during PSF for idiopathic scoliosis. The demographic data obtained included age, weight, height, body mass index, and gender. Orthopedic data included Lenke grade, preoperative and postoperative Cobb angle, and levels fused. Premedication with oral or intravenous midazolam was administered as needed. No dexamethasone, labetolol or anticholinergic agents were administered perioperatively. Routine American Society of Anesthesiologists’ monitors were placed. For the volatile-based group, anesthetic induction included the inhalation of increasing concentrations of sevoflurane in 50-70% nitrous oxide in oxygen. For the TIVA group, a peripheral intravenous cannula was placed after the patient was breathing 50-70% nitrous oxide in oxygen and the local infiltration of 1% lidocaine over the insertion site. Anesthesia was then induced with propofol (2-3 mg/kg). In both groups, fentanyl (2-3 µg/kg) and rocuronium (0.3 mg/kg) were administered following the induction of anesthesia. Two peripheral intravenous cannulae and an arterial cannula were then placed. Additional doses of rocuronium (0.2 mg/kg) were administered as needed during dissection of the paraspinal muscles. Maintenance anesthesia consisted of a propofol infusion or inhaled desflurane, both of which were adjusted to maintain the bispectral index (BIS) at 40-60 to ensure amnesia and an equivalent depth of anesthesia between the two groups. A remifentanil infusion was administered starting at 0.1 µg/kg/min and increased up to 1 µg/kg/min to maintain the mean arterial pressure (MAP) at 55-65 mmHg. Hydralazine (0.1-0.2 mg/kg) was administered as needed to keep the MAP at 55-65 mmHg. Neurophysiologic monitoring included SSEP P31 and P37 from the left and right sides while MEP information included the amplitude required to elicit a response.
Information regarding the intraoperative course included anesthesia time, surgical time, intraoperative fluids (crystalloid, colloid, and blood products), estimated blood loss, and recovery characteristics upon completion of the procedure (time to eye opening, following commands, tracheal extubation). Additionally, the BIS, heart rate (HR), blood pressure (BP), MAP, oxygen saturation, propofol dose or end-tidal desflurane concentration, and the remifentanil infusion rate were noted every 30 minutes.

Once neurophysiological monitoring was completed, the propofol and remifentanil infusions were discontinued. Desflurane was then used in both groups to maintain the BIS at 50-70 and hydromorphone administered in increments of 0.2 mg based on the respiratory rate. Acetaminophen (15 mg/kg) to a maximum dose of 1000mg and ondansetron (4 mg) were administered intravenously. Pain scores and total hydromorphone requirements (in the operating room and the post-anesthesia care unit) were recorded.

**Results**

The study cohort included 30 adolescents ranging in age from 11 years to 20 years and in weight from 37 to 88 kilograms scheduled for PSF in the treatment of adolescent idiopathic scoliosis. Each group of patients contained 15 patients of which 14 of the 15 in each group were females. The groups were similar in regards to age, weight, height, and body mass index. They were also similar in average Cobb angle of the primary curve. There was a similar distribution of Lenke classifications in each group as well as the final implant density (table 1). The intraoperative data are outlined in table 2. There was no difference in the anesthesia time, surgery time, intraoperative fluids, and estimated blood loss between the two groups (table 2). No clinically significant difference was noted in the amplitude or latency of SSEP monitoring (table 4, figures 1 & 2). Although there were statistically significant differences at various points in the latency value for SSEP, the largest difference between the two
groups in the latency was 1.9 milliseconds. A significantly greater voltage amplitude was required to generate a MEP during volatile anesthesia; however, the amount was within the clinically accepted range (table 5 and figure 3). Time to eye opening, time to following commands, and time to tracheal extubation were all shorter in the inhaled anesthesia group when compared to the TIVA group (table 3). Three patients in each group required additional antihypertensive therapy with hydralazine to maintain goal mean arterial pressures. Hydromorphone consumption across all time points perioperatively and in 24 hours was not significantly different (table 3). The differences in remifentanil requirements intraoperatively, both total consumption and weight based values, were not statistically significant. There was no difference in hospital length of stay.

**Discussion**

Various options are available for the provision of intraoperative anesthesia during surgical procedures including both inhaled and intravenous agents. The general consensus when providing anesthesia for PSF is to use a TIVA technique or a low dose propofol infusion (50 µg/kg/min) combined with a low inhaled concentration of a volatile agent (less than 0.5 MAC). Our clinical practice has generally involved the use of a volatile agent (desflurane) combined with the short acting opioid, remifentanil, during these cases. This practice has demonstrated that both SSEP’s and MEP’s can be obtained with this anesthetic technique. The current randomized prospective study demonstrates that neurophysiological monitoring is feasible when using a volatile agent as the primary anesthetic during such procedures and that there are few if any clinically significant differences between the two techniques in regards to efficacy of neurophysiological monitoring. We noted no clinically significant differences in the amplitude or latency of SSEP monitoring. Although a significantly higher voltage
Amplitude was needed to elicit a response, the amount necessary was within those commonly used in clinical practice.

Even though propofol is in widespread use in these cases, there may be specific concerns including prolonged awakening times, lipemia, alteration of platelet function, and the development of metabolic acidosis.\textsuperscript{8-11} Propofol has been shown in specific patients to impair mitochondrial function, but this is of limited concern during short procedures.\textsuperscript{13,14} The volatile-based anesthetic technique indeed resulted in faster wake-up times as shown through earlier extubation times, shorter time to follow commands, and faster times to eye opening. Although the difference was moderate, the potential effect of propofol was limited as it was discontinued when neurophysiological monitoring was no longer necessary thereby allowing 30-60 minutes from its discontinuation to the completion of the case. In the event that a wake-up test were necessary, it is likely that the time to awakening would be even longer given the contest sensitive half-life of propofol when compared to desflurane.

In summary, our data demonstrate that a volatile-based anesthetic regimen is feasible even during neurophysiological monitoring. Advantages include a more rapid awakening and the feasibility of a rapid wake-up test (less than 5 minutes) in the event that irreversible changes in neurophysiological monitoring are noted. When this technique is used, we believe that depth of anesthesia monitoring is an integral component to the success of the technique. By employing bispectral index (BIS) monitoring, we ensured that the minimal amount of the inhaled agent to maintain amnesia was used. The remifentanil infusion was titrated to maintain hemodynamic stability while the volatile agent was titrated to maintain the BIS at 40-60. The use of higher concentrations of the volatile agent is not recommended as impairment of MEP monitoring is quite likely to occur. Despite the success of the current technique, volatile agents may be contraindicated in specific patient populations including those with muscular dystrophies. In that setting, a TIVA technique may still be appropriate.\textsuperscript{15-18} Although our clinical
practice continues to routinely use the volatile based regimen as our preferred technique, in our population of approximately 200 posterior spinal procedures a year, we have noted an incidence of approximately 1% which mandates a switch to a TIVA technique because appropriate neurophysiological monitoring is not feasible. We must emphasize that the current study was not powered to detect this incidence, compare its incidence to a TIVA technique or determine its clinical significance. The goal was to validate the clinical utility of our current practice using a volatile anesthetic (desflurane) based technique. In the small cohort of 30 patients, problems with neurophysiological monitoring were not noted. If there is difficulty obtaining motor evoked potentials or if concerns arise during the course of the anesthetic, we would switch to a TIVA approach to potentially improve neurophysiological monitoring. It has been previously demonstrated that neurophysiological monitoring is the standard of care as it can reduce the incidence of neurological injury. However, the current study was not designed to determine if the incidence of neurological injury is different based on the anesthetic technique (volatile agent vs. TIVA). Given the low incidence of such issues with neurophysiological monitoring, such a study would likely require a 10-fold increase in the study cohort.

During either a volatile anesthesia based or TIVA technique, we believe that depth of anesthesia monitoring is useful as excessive depth of anesthesia related to either technique can affect neurophysiological monitoring. Depth of anesthesia monitoring is also useful if the clinical situation demands switching from a volatile based to a TIVA technique to avoid excessive depth of anesthesia during the transition. Given the rapid recovery that is noted following a desflurane-remifentanil technique, aggressive pain management prior to emergence is necessary. In our patients, hydromorphone was administered prior to the completion of the surgical procedure to ensure adequate analgesia during recovery. With these caveats in mind, a volatile agent based technique remains our primary anesthesia during PSF with neurophysiological monitoring.
References


**Figure 1:** Changes in latency of the somatosensory evoked response over time. The time is listed on the horizontal (x axis) and the latency in milliseconds is shown on the vertical (y axis).

**Figure 2:** Changes in amplitude of the somatosensory evoked response over time. The time is listed on the horizontal (x axis) and the amplitude is shown on the vertical (y axis).
Figure 3: Changes in milliamps required to elicit a motor evoked potential over time.

The time is on the vertical (x axis) and the voltage (milliamps) required to elicit the response is listed on the y axis.

Table 1: Demographic & orthopedic data of the study groups

<table>
<thead>
<tr>
<th>Group</th>
<th>Number</th>
<th>Male/Female</th>
<th>Age (years)</th>
<th>Height (cm)</th>
<th>Weight (kg)</th>
<th>BMI (kg/m²)</th>
<th>ASA 1, 2, 3</th>
<th>Primary curve Cobb angle</th>
<th>Lenke 1, 2, 3, 4, 5, 6</th>
<th>Implant Density</th>
</tr>
</thead>
<tbody>
<tr>
<td>TIVA</td>
<td>15</td>
<td>1/14</td>
<td>14.5 ± 2.1</td>
<td>158.8 ± 6.7</td>
<td>54.9 ± 13.1</td>
<td>22 ± 5</td>
<td>3, 12, 0</td>
<td>60 ± 11</td>
<td>4, 4, 3, 0, 3, 1</td>
<td>1.84 ± 0.09</td>
</tr>
<tr>
<td>Volatile</td>
<td>15</td>
<td>1/14</td>
<td>15.4 ± 2.4</td>
<td>165.1 ± 9.0</td>
<td>55.3 ± 10.1</td>
<td>20 ± 4</td>
<td>3, 11, 1</td>
<td>57 ± 13</td>
<td>6, 2, 2, 0, 2, 3</td>
<td>1.82 ± 0.15</td>
</tr>
</tbody>
</table>
**TIVA = total intravenous anesthesia; BMI = body mass index; P=NS for all data between the two groups**

**Table 2: Perioperative data**

<table>
<thead>
<tr>
<th>Group</th>
<th>Surgery Time</th>
<th>Time to eye opening</th>
<th>Time to follow commands</th>
<th>Time to tracheal extubation</th>
<th>Total intravenous fluids (mL)</th>
<th>Total blood loss (mL)</th>
<th>Number of patients needing antihypertensives</th>
</tr>
</thead>
<tbody>
<tr>
<td>TIVA</td>
<td>4:18 ± 1:19</td>
<td>0:05 ± 0:05</td>
<td>0:06 ± 0:03</td>
<td>0:06 ± 0:03</td>
<td>2171 ± 746</td>
<td>363 ± 152</td>
<td>3</td>
</tr>
<tr>
<td>Volatile</td>
<td>3:16 ± 1:25</td>
<td>0:01 ± 0:00</td>
<td>0:01 ± 0:01</td>
<td>0:01 ± 0:01</td>
<td>2089 ± 1095</td>
<td>399 ± 248</td>
<td>3</td>
</tr>
<tr>
<td><strong>p value</strong></td>
<td>NS</td>
<td>0.006</td>
<td>0.0001</td>
<td>0.0001</td>
<td>NS</td>
<td>NS</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Group</th>
<th>Propofol dose or end-tidal desflurane concentration 60 min</th>
<th>Propofol dose or end-tidal desflurane concentration 2 hours</th>
<th>Propofol dose or end-tidal desflurane concentration 3 hours</th>
<th>Propofol dose or End-tidal desflurane concentration 4 hours</th>
<th>Propofol dose or end-tidal desflurane concentration 5 hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>TIVA</td>
<td>137 ± 38.35</td>
<td>125 ± 34.9</td>
<td>106.07 ± 42.57</td>
<td>102.5 ± 41.15</td>
<td>84.38 ± 37.65</td>
</tr>
<tr>
<td>Volatile</td>
<td>4.1 ± 0.77</td>
<td>4.18 ± 0.63</td>
<td>4.03 ± 0.41</td>
<td>3.93 ± 0.39</td>
<td>4.18 ± 1.07</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Group</th>
<th>Remifentanil maximum Dose (µg/kg/minute)</th>
<th>Total remifentanil administered (µg)</th>
<th>Total remifentanil (µg/kg)</th>
<th>Total perioperative hydromorphone (mg in OR and the PACU)</th>
<th>Average pain score in the PACU</th>
</tr>
</thead>
<tbody>
<tr>
<td>TIVA</td>
<td>0.68 ± 0.3</td>
<td>7494.6 ± 4703.53</td>
<td>127.28 ± 62.6</td>
<td>1.38 ± 0.7</td>
<td>4.2 ± 3.7</td>
</tr>
<tr>
<td>Volatile</td>
<td>0.65 ± 0.26</td>
<td>6266.86 ± 3409.18</td>
<td>109.22 ± 60.61</td>
<td>1.74 ± 0.79</td>
<td>4.9 ± 3.7</td>
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<tr>
<td><strong>p value</strong></td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
</tbody>
</table>

TIVA = total intravenous anesthesia; OR = operating room; PACU = post-anesthesia care unit; The propofol dose is presented as µg/kg/min while the end-tidal desflurane concentration is expired concentration (percentage).
### Table 3: Postoperative data

<table>
<thead>
<tr>
<th>Group</th>
<th>24 hour hydromorphone requirements (OR + PACU + Floor)</th>
<th>24 hour hydromorphone requirements (mg/kg)</th>
<th>Average pain score over initial 24 hours</th>
<th>Length of hospital stay (days)</th>
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</thead>
<tbody>
<tr>
<td>TIVA</td>
<td>13.14 ± 4.61</td>
<td>0.24 ± 0.08</td>
<td>4.3 ± 3.2</td>
<td>4.1 ± 1.1</td>
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<tr>
<td>Volatile</td>
<td>16.83 ± 7.87</td>
<td>0.31 ± 0.14</td>
<td>4.7 ± 3.1</td>
<td>4.2 ± 0.9</td>
</tr>
<tr>
<td>p value</td>
<td>0.1356</td>
<td>0.1555</td>
<td>0.1493</td>
<td></td>
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</table>

TIVA = total intravenous anesthesia; OR = operating room; PACU = post-anesthesia care unit

### Table 4: Somatosensory latency & amplitude data

<table>
<thead>
<tr>
<th>Group</th>
<th>P31 Right Latency Pre-Op</th>
<th>P31 Left Latency Pre-Op</th>
<th>P31 Right Amplitude Pre-Op</th>
<th>P31 Left Amplitude Pre-Op</th>
<th>P37 Right Latency Pre-Op</th>
<th>P37 Left Latency Pre-Op</th>
<th>P37 Right Amplitude Pre-Op</th>
<th>P37 Left Amplitude Pre-Op</th>
<th>P31 Right Latency Baseline</th>
<th>P31 Left Latency Baseline</th>
<th>P31 Right Amplitude Baseline</th>
<th>P31 Left Amplitude Baseline</th>
<th>P31 Right Latency 30 min</th>
<th>P31 Left Latency 30 min</th>
<th>P37 Right Amplitude 30 min</th>
<th>P37 Left Amplitude 30 min</th>
<th>P37 Right Latency 30 min</th>
<th>P37 Left Latency 30 min</th>
</tr>
</thead>
<tbody>
<tr>
<td>TIVA</td>
<td>27.6 ± 1.9</td>
<td>0.83 ± 0.4</td>
<td>27.3 ± 1.8</td>
<td>0.91 ± 0.37</td>
<td>35.8 ± 2.0</td>
<td>1.95 ± 1.7</td>
<td>35.1 ± 1.5</td>
<td>2.03 ± 1.14</td>
<td>27.6 ± 1.6</td>
<td>0.92 ± 0.28</td>
<td>27.6 ± 1.6</td>
<td>0.89 ± 0.26</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
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<tr>
<td>Volatile</td>
<td>28.2 ± 2</td>
<td>0.84 ± 0.25</td>
<td>28.8 ± 2.3</td>
<td>0.73 ± 0.41</td>
<td>36.7 ± 2.3</td>
<td>1.57 ± 1.05</td>
<td>36.0 ± 2</td>
<td>1.57 ± 0.88</td>
<td>29.4 ± 2.1</td>
<td>0.83 ± 0.24</td>
<td>29.3 ± 2.2</td>
<td>0.85 ± 0.37</td>
<td>NS</td>
<td>NS</td>
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<td>p value</td>
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<td>NS</td>
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<td>NS</td>
<td>NS</td>
<td>0.02 ± 31</td>
<td>NS</td>
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<th>1.9</th>
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<th>1.6</th>
<th>1.18</th>
<th>2.2</th>
<th>0.30</th>
<th>1.7</th>
<th>0.23</th>
<th>1.8</th>
<th>1.03</th>
<th>1.6</th>
<th>0.90</th>
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<tr>
<td>Volatile</td>
<td>37.9 ± 2.4</td>
<td>1.72 ± 1.39</td>
<td>37.4 ± 2</td>
<td>1.52 ± 1.16</td>
<td>29.3 ± 2.1</td>
<td>0.67 ± 0.27</td>
<td>29.1 ± 2</td>
<td>0.77 ± 0.28</td>
<td>37.1 ± 2.5</td>
<td>1.21 ± 1.01</td>
<td>36.4 ± 2.2</td>
<td>1.08 ± 0.78</td>
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<td>p value</td>
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<td>TIVA</td>
<td>27.6 ± 1.5</td>
<td>0.87 ± 0.25</td>
<td>27.6 ± 1.7</td>
<td>0.73 ± 0.22</td>
<td>37.1 ± 2.0</td>
<td>1.44 ± 1.25</td>
<td>36.1 ± 1.6</td>
<td>1.52 ± 1.30</td>
<td>27.8 ± 1.7</td>
<td>0.75 ± 0.19</td>
<td>27.6 ± 1.3</td>
<td>0.67 ± 0.18</td>
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<tr>
<td>Volatile</td>
<td>29.2 ± 2.1</td>
<td>0.75 ± 0.33</td>
<td>28.9 ± 2.6</td>
<td>0.81 ± 0.27</td>
<td>37.4 ± 2.6</td>
<td>1.15 ± 0.87</td>
<td>36.7 ± 2.7</td>
<td>1.06 ± 0.79</td>
<td>29.4 ± 2.5</td>
<td>0.78 ± 0.35</td>
<td>29.2 ± 2.3</td>
<td>0.77 ± 0.25</td>
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<td>p value</td>
<td>0.025</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>0.028</td>
<td>NS</td>
</tr>
</tbody>
</table>

TIVA = total intravenous anesthesia; Inst. = instrumentation
Table 5: Motor evoked potential data

<table>
<thead>
<tr>
<th>Group</th>
<th>Baseline: left</th>
<th>Baseline: right</th>
<th>30 minutes: left</th>
<th>30 minutes: right</th>
<th>Post anchor: left</th>
<th>Post anchor: right</th>
<th>Instrumentation complete: left</th>
<th>Instrumentation complete: Right</th>
</tr>
</thead>
<tbody>
<tr>
<td>TIVA</td>
<td>315 ± 77</td>
<td>315 ± 77</td>
<td>316 ± 86</td>
<td>320 ± 82</td>
<td>295 ± 66</td>
<td>298 ± 61</td>
<td>295 ± 66</td>
<td>298 ± 61</td>
</tr>
<tr>
<td>Volatile</td>
<td>431 ± 69</td>
<td>435 ± 80</td>
<td>408 ± 84</td>
<td>415 ± 77</td>
<td>411 ± 88</td>
<td>414 ± 86</td>
<td>411 ± 88</td>
<td>414 ± 86</td>
</tr>
<tr>
<td>p value</td>
<td>0.0002</td>
<td>0.0003</td>
<td>0.0066</td>
<td>0.0028</td>
<td>0.0003</td>
<td>0.0003</td>
<td>0.0004</td>
<td>0.0002</td>
</tr>
</tbody>
</table>

TIVA = total intravenous anesthesia; the data are listed as the milliamps required to elicit the motor response.