Sedation during neuroaxial anesthesia is often performed to increase patient acceptance or satisfaction of anesthetic techniques, improve surgical conditions, or prevent the recall of unpleasant events during surgery. However, according to the continuity hypothesis, formulated by Hall and Nordby, dreams express both awakening concerns and emotional preoccupations, and any physiological processes from both external and internal stimuli can affect dream content. Thus, as patients dream during supplemental sedation, they may have to cope with the physical and emotional sequelae of their illness, and unpleasant numbness in the lower limbs due to neuroaxial anesthesia. Similarly, they may have to cope with the sensory overload due to the continuous noise and lighting in the operating room.

As with dreams after general anesthesia, many features of dreams reported after procedural sedation were similar to those of natural sleep. A previous study on dreaming after general anesthesia found that dreaming made the patients more depressed and anxious postoperatively, and less satisfied with anesthetic care. Therefore, we hypothesize that unpleasant intraoperative dreams may negate the benefits obtained from supplemental sedation in surgical patients undergoing neuroaxial anesthesia. Currently, there are no available data regarding the effects of particular sedative drugs on the details of dreaming in these situations. The current prospective study was designed to compare 2 different IV sedation protocols (propofol and midazolam infusion) in surgical patients undergoing spinal anesthesia with respect to the incidence, nature, and content of dreaming during sedation. Additionally, we examined the impact of dreaming on patient satisfaction with sedation.

METHODS
The study protocol was approved by the hospital ethics committee. Written informed consent was obtained from all of the participating patients.

Two hundred twenty surgical patients, ages 18 to 70 years, ASA physical status I–III, scheduled for spinal anesthesia with supplemental sedation, were enrolled in this study. Those with cognitive deficits or intellectual impairments, those with psychotic or major affective disorders, and those who had taken hypnotics were excluded. The eligible patients were randomly assigned into 2 groups of 110 subjects each using a computer-generated table of random numbers to receive IV infusion of either propofol or midazolam for sedation during surgical procedures. All of the patients and a single research anesthesiologist, who...
performed all the postoperative interviews and dream data collections, were blinded to the group allocation.

**Procedure**

None of the patients received premedication. After fluid administration with 500 mL of lactated Ringer’s solution, spinal anesthesia was administered with a 25-G Quincke spinal needle at the L3 to 4 or L4 to 5 intervertebral space using 2.4 to 2.8 mL of 0.5% hyperbaric bupivacaine. Oxygen was administered at 6 L/min through a mask during the procedure. Intraoperative monitoring included electrocardiography, pulse oximetry, noninvasive sphygmomanometry, and capnography. When the anesthetic level was adequate for surgery, the infusion of sedatives was initiated. In the propofol group, the infusion of propofol at 10 mg/kg/h was initiated after the administration of a 20-mg bolus of lidocaine. We asked the patients to keep their eyes open at the start of the sedation. When patients closed their eyes spontaneously, the infusion dose was reduced to 5 mg/kg/h. In the midazolam group, the infusion of midazolam was initiated at 1.0 mg/kg/h. As soon as the patients closed their eyes spontaneously, the infusion dose was decreased to 0.5 mg/kg/h.

Sedation was assessed using a 5-point sedation scale: 1 = fully awake and oriented; 2 = drowsy; 3 = eyes closed but responded to verbal commands; 4 = eyes closed but responded to mild physical stimulation, such as an earlobe tug; 5 = eyes closed and unresponsive to mild physical stimulation. Sedation was measured every minute for the first 5 minutes and then at 5-minute intervals until the end of surgery. In both groups, the infusion dose was decreased to half or increased to double to maintain a sedation score between 4 and 5. At the end of surgery, the sedative infusion was stopped.

**Data Collection**

The onset time of sedation was defined as the time taken from the start of infusion to reach spontaneous eye closure, and the offset time of sedation was defined as the time from the end of infusion to complete patient awakening (oriented to time, place, and person). The following complications were recorded during sedation: the presence of bradycardia (heart rate <50 beats per minute [bpm], or 20% less than the baseline), hypotension (systolic blood pressure <80 mm Hg, or 20% less than the baseline), oxygen desaturation (SpO₂ <95%), apnea (absence of expired carbon dioxide in capnography or respiratory movement for >15 seconds), or involuntary movement impeding the surgical procedure.

When the patients initially emerged from sedation and were oriented to the time, place, and person, they were asked the following standardized questions:

1. “What was the last thing you remember before going to sleep?”
2. “What was the first thing you remember when you woke up?”
3. “Can you recall anything in between?”
4. “Did you have any dreams during sedation?”

Thirty minutes later, the patients had a second interview and were asked the same questions. Dreaming during sedation was defined as any experience (excluding the explicit recall of intraoperative events) that was described by the patients as dreaming and was thought by the patient to have occurred between the induction of sedation and the first moment of consciousness after sedation.

When dreaming was reported, a narrative report was collected and the nature of the dream was assessed by the research anesthesiologist. Additionally, all dream narrative reports were reviewed again to investigate the relationship between the contents of dreams and intraoperative events by the attending anesthesiologists. The patients were then asked to complete a 5-point Likert-type scale on 5 items regarding the dream. These were as follows:

1. Emotional content (1 = very negative; 5 = very positive).
2. Memorability (1 = only remember dreaming; 5 = very memorable).
3. Visual vividness (1 = not at all vivid; 5 = very vivid).
4. Emotional intensity (1 = not at all intense; 5 = very intense).
5. Strangeness (1 = not at all strange; 5 = very strange).

If assessment of the 5 items on the 5-point scales and narrative reporting about the dream could be completed in the first interview, they were not repeated in the second interview. All subjects reporting dreaming in either of the 2 interview periods were considered “dreamers” in further analysis, regardless of whether they could remember the narrative of the dream. Patient satisfaction with the sedation was rated on a 101-point numerical rating scale (0 = no satisfaction, 100 = maximum satisfaction) at the second interview.

**Statistical Analyses**

The primary end point was the difference in the proportion of the dreamers between the propofol and midazolam groups, which was estimated as 36% in the propofol group, inferred from the rates of dreaming reported after general anesthesia. We considered a 50% reduction of this incidence in the midazolam group as clinically significant. On the basis of these figures, using \( \alpha = 0.05 \) and \( \beta = 0.2 \), for a clinical study design incorporating 2 groups of equal size, we calculated that a sample size of 106 patients per group would be required. Therefore, we enrolled 110 patients per group to compensate for possible dropouts.

Categorical variables were compared using Pearson \( \chi^2 \) tests with continuity correction or Fisher exact test, as applicable. Continuous variables were tested for normality using the Kolmogorov–Smirnov test. Normally distributed variables were described as the mean ± SD and compared using the unpaired 2-tailed \( t \) test. Likert scores on the assessment of the 5 items regarding the dreams were described as medians (interquartile range) and compared using Wilcoxon’s ranked-sum test. The SPSS package (version 13.0; SPSS Inc., Chicago, Illinois) was used for statistical analysis. In all cases, statistical significance was defined as \( P < 0.05 \).

**RESULTS**

Eleven patients were screened by our exclusion criteria, and 220 patients were subsequently allocated to 2 groups of
Table 1. Demographic and Intraoperative Data

<table>
<thead>
<tr>
<th></th>
<th>Propofol (n = 108)</th>
<th>Midazolam (n = 107)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender (M/F)</td>
<td>75/33</td>
<td>84/23</td>
<td>0.162</td>
</tr>
<tr>
<td>Age (years)</td>
<td>36.8 ± 14.2</td>
<td>40.4 ± 15.1</td>
<td>0.075</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>68.6 ± 9.9</td>
<td>69.0 ± 8.7</td>
<td>0.755</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>169.4 ± 8.8</td>
<td>169.9 ± 8.6</td>
<td>0.663</td>
</tr>
<tr>
<td>ASA physical status (I/II/III)</td>
<td>81/21/6</td>
<td>84/18/5</td>
<td>0.830</td>
</tr>
<tr>
<td>Duration of surgery (minutes)</td>
<td>77.6 ± 46.6</td>
<td>69.7 ± 34.6</td>
<td>0.160</td>
</tr>
<tr>
<td>Duration of anesthesia (minutes)</td>
<td>101.4 ± 49.5</td>
<td>93.1 ± 38.8</td>
<td>0.174</td>
</tr>
<tr>
<td>Duration of sedative infusion (minutes)</td>
<td>74.5 ± 48.1</td>
<td>66.3 ± 33.2</td>
<td>0.149</td>
</tr>
</tbody>
</table>

Data are expressed as mean ± SD or number. ASA = American Society of Anesthesiologists; M = male; F = female.

Table 2. Onset and Offset of Sedation and Number of Patients with Side Effects

<table>
<thead>
<tr>
<th></th>
<th>Propofol (n = 108)</th>
<th>Midazolam (n = 107)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Onset of sedation (seconds)</td>
<td>250.8 ± 67.4</td>
<td>257.4 ± 60.4</td>
<td>0.451</td>
</tr>
<tr>
<td>Offset of sedation (seconds)</td>
<td>270.5 ± 112.6</td>
<td>304.1 ± 128.9*</td>
<td>0.043</td>
</tr>
<tr>
<td>Hypotension</td>
<td>13 (12.0%)</td>
<td>3 (2.8%)</td>
<td>0.020</td>
</tr>
<tr>
<td>Bradycardia</td>
<td>16 (14.8%)</td>
<td>6 (5.6%)*</td>
<td>0.045</td>
</tr>
<tr>
<td>Desaturation</td>
<td>2 (0.9%)</td>
<td>4 (3.7%)</td>
<td>0.670</td>
</tr>
<tr>
<td>Apnea</td>
<td>12 (11.1%)</td>
<td>9 (8.4%)</td>
<td>0.662</td>
</tr>
<tr>
<td>Involuntary movement</td>
<td>1 (0.9%)</td>
<td>3 (2.8%)</td>
<td>0.369</td>
</tr>
</tbody>
</table>

Data are expressed as mean ± SD or number (proportion). * Statistically significant difference (P < 0.05).

In cases of spinal anesthesia with supplemental sedation, the incidence of dreaming was 39.8% in patients receiving midazolam infusion (Figure 1; P < 0.05). A similarly high level of patient satisfaction with the sedation was expressed in both groups (Table 3). In subgroup analyses, the dreamers displayed a higher satisfaction score with sedation than did nondreamers in the propofol group (92.8 ± 9.3 vs. 87.2 ± 11.8; P = 0.01). However, no significant difference in satisfaction score with the sedation was observed between dreamers and nondreamers in the midazolam group (82.9 ± 16.0 vs. 88.6 ± 10.3; P = 0.09).

**DISCUSSION**

In cases of spinal anesthesia with supplemental sedation, the incidence of dreaming was 39.8% in patients receiving propofol infusion. This was consistent with previous studies, which indicated incidence rates of 35.5% or 36% after propofol-based anesthesia.

However, the use of midazolam was associated with a decreased likelihood of intraoperative dreaming versus propofol (12.1% vs. 39.8%). This was supported by a previous study indicating incomplete and less effective amnesia after sedation with propofol than with midazolam, although this was proportional to the dose of propofol administered. Another possible explanation is that patients receiving propofol emerged more rapidly and clearly from sedation and were able to communicate earlier and more clearly with the interviewer than did those receiving midazolam. In this study, those patients receiving propofol

Table 3. Incidences of Awareness and Dreaming During Sedation

<table>
<thead>
<tr>
<th></th>
<th>Propofol (n = 108)</th>
<th>Midazolam (n = 107)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dreaming at first interview</td>
<td>39 (36.1%)</td>
<td>10 (9.3%)*</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Dreaming at second interview</td>
<td>39 (35.2%)</td>
<td>11 (10.3%)*</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Total incidence of the dreaming</td>
<td>43 (39.8%)</td>
<td>13 (12.1%)*</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Satisfaction with the sedation score (0–100)</td>
<td>89.4 ± 11.2</td>
<td>87.9 ± 11.2</td>
<td>0.972</td>
</tr>
</tbody>
</table>

Data are expressed as mean ± SD or number (proportion). * Statistically significant difference (P < 0.05).

Table 4. Dream Contents (n = 56) in Both Groups

<table>
<thead>
<tr>
<th>Dream content</th>
<th>Typical examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pleasant ruminations about everyday life (n = 36)</td>
<td>Travelling to somewhere with friends. Dream about work or a plan to do something.</td>
</tr>
<tr>
<td>Dreams about the imaginary experiences of operation (n = 5)</td>
<td>Going to the ward after the successful operation. The surgery being performed successfully.</td>
</tr>
<tr>
<td>Being pursued by someone (n = 6)</td>
<td>Being on the run from the surgeon because he forced me to eat a spoiled hamburger. Being chased by a scary man.</td>
</tr>
<tr>
<td>Unclassified form (n = 4)</td>
<td>Flying to the sea with a cartoon character. Mining for gold in a mountain.</td>
</tr>
<tr>
<td>Dream in which the storyline could not be remembered (n = 5)</td>
<td></td>
</tr>
</tbody>
</table>

equal size. Two patients in the propofol group and 3 patients in the midazolam group were excluded because of conversion to general anesthesia or the use of supplemental IV opioids due to inadequate spinal anesthesia for surgery. Finally, 108 subjects in the propofol group and 107 subjects in the midazolam group were included in the analysis.

Patient characteristics were similar in the 2 groups, and no significant difference was observed between the groups with respect to the duration of surgery, anesthesia, or sedation (Table 1). Propofol infusion caused a more rapid awakening (oriented to time, place, and person), but more frequent episodes of hypotension and bradycardia during sedation than did midazolam infusion (Table 2).
showed more rapid awakening than did those receiving midazolam. A higher incidence of dreaming has been reported in patients who were interviewed as soon as they emerged from anesthesia.5,13 In one study, patients receiving propofol for maintenance of general anesthesia reported higher incidences of dreaming than did patients maintained with desflurane, though recovery time profiles were similar in both groups.7 It was suggested in another study that the higher incidence of dreaming in propofol maintenance may be attributed, at least in part, to its pharmacological action.13

On the basis of previous studies showing that emotional preoccupations in waking life as well as the external or internal stimuli presented during sleep could affect dream content,1–4 we initially hypothesized that the majority of intraoperative dreams might be unpleasant or bad in nature. Bokert3 studied the effects of thirst on dreams and found that beverage and water themes in the dreams of thirsty subjects were more frequent because of a direct physiological effect from internal stimuli or a continuity effect of thinking about water and drinking before sleep. However, contrary to our hypothesis, the majority of dreams in the current study (36 of 56 dreamers, 64.3%) were simple, pleasant ruminations about everyday life. They were similar in nature to the dreams after general anesthesia.5,13

Dreams that included imaginary experiences of the operation were reported in 5 cases. However, additional careful investigations by the attending anesthesiologists showed that these contents were not related to the actual surgical events. When considering that the significance of dreaming during sedation depends on whether patients are troubled by dreaming, these dreams related to surgery, events, or conversations occurring during sedation are important. In cases of general anesthesia, some patients reported intraoperative dreaming as a distressing part of their hospital visit because they may confuse their dream with awareness, especially if the content of the dream relates to the operative setting.5,7,11 This has also been reported in patients who were mechanically ventilated and sedated in the intensive care unit18 and in those undergoing procedural sedation in the emergency department.19 In a minority of cases, some patients experienced similar consequences to those who have suffered intraoperative awareness during general anesthesia, including posttraumatic stress disorder.18,20 Thus, anesthesiologists should assist patients in understanding that the dream was not associated with inadequate sedation, even if it was not related to the explicit recall of intraoperative events.

In the dream narratives in this study, dreams of being pursued by someone, which has seldom been reported after general anesthesia, were reported in 6 of 46 dreamers (10.7%). Paradoxically, this may have been related to the experience of lower-limb paralysis after spinal anesthesia, which was unpleasant and somewhat horrific to the patients before sedation.

In this study, the anesthesia level was monitored in all patients so as to be sufficient for the planned surgery before initiating sedation. Thus, 5 patients in both groups were excluded because of inadequate spinal anesthesia for surgery. The reason was that realistic localized pain sensations can also be experienced in dreams, either through direct incorporation21 or from past memories of pain.22

Despite the significant difference in the incidence of dreaming, both groups showed similarly high levels of patient satisfaction with the sedation. This was contrary to the study of Leslie et al., who found that dreamers were less satisfied with anesthetic care than were nondreamers.7 This difference may have occurred because more patients who report dreaming after general anesthesia fear that their anesthetic was inadequate and thus confuse intraoperative dreams with awareness than do patients who report dreaming after sedation. Although the emotional contents of the dreams in both groups were similarly positive, those

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**Figure 1.** Five-point Likert-type scale values for narratives of dream reports from the “dreamers” of both groups (43 patients in the propofol group and 13 patients in the midazolam group). Shaded rectangular areas represent the interquartile ranges of the Likert scores, and the bold lines represent the median of the Likert scores. Emotional content (1 = very negative, 5 = very positive), memorability (1 = only remember dreaming, 5 = very memorable), visual vividness (1 = not at all vivid, 5 = very vivid), emotional intensity (1 = not at all intense, 5 = very intense), strangeness (1 = not at all strange, 5 = very strange). *P < 0.05 between the propofol and midazolam groups.
patients receiving propofol infusion displayed more memorable and visually vivid dreams than did those receiving midazolam infusion. This may be attributed to a higher satisfaction score regarding the sedation in dreamers in comparison with nondreamers in the propofol group. However, as differences in satisfaction scores regarding the sedation between the dreamers and nondreamers were not the major outcome factor of our study, the overall impact of this study is not sufficient and as such, further studies are required regarding this issue.

There are some potential limitations to our study design. First, the details of dreaming during lighter sedation may be different from those of dreaming during the deep sedation applied in this study. Generally, sedation can be described as 4 progressive depths of minimal (anxiolysis), moderate, and deep sedation followed by anesthesia. In this regard, we applied a continuous infusion instead of an intermittent bolus technique to provide a constant sedation level. Additionally, we measured the sedation score regularly to monitor sedation levels.

Second, no neurophysiologic monitoring was performed in this study. Thus, it is unclear whether our main observations were the result of more actual dreaming episodes or less amnesia for the dreams in patients receiving propofol infusion. There is always this essential problem with any studies of this kind without the development of reliable neurophysiologic monitoring tools. In this regard, the recent research of Leslie et al.23 is considered a notable achievement for demonstrating the association of anesthetic-related dreaming with some electroencephalographic findings. Definitely, what we now need in dream research in the field of anesthesiology is a clear understanding of the neural correlates of intraoperative dreaming as well as a clearer understanding of the interface of anesthetic states, sedation states, and normal sleep states. However, it should be accompanied with psychological approaches, which were used in part in this study, for better understanding of intraoperative dreaming.

Finally, patients were interviewed twice, increasing the likelihood of the detection of dreaming. However, the dreams reported by patients at the second interview, and not the first (6 patients in both groups), may have occurred between the 2 interviews and not during sedation at all, although residual sedative effects at the first interview may have impaired memory retrieval in some cases.

In conclusion, in cases of spinal anesthesia with supplemental sedation, intraoperative dreaming (or at least postoperative dream recall) was almost 5 times more common in patients receiving propofol infusion than in those receiving midazolam. However, the differences in the incidences of dreaming did not influence patient satisfaction with the sedation. Most dreams in both groups were pleasant, harmless, and unrelated to the surgical events, similar to those dreams reported after general anesthesia. Thus, one need not consider intraoperative dreaming when choosing propofol or midazolam as a sedative drug in patients undergoing spinal anesthesia.

**REFERENCES**


**DISCLOSURES**

**Name:** Duk-Kyung Kim, MD, PhD.
**Contribution:** This author helped design the study, conduct the study, analyze the data, and write the manuscript.

**Attestation:** Duk-Kyung Kim has seen the original study data, reviewed the analysis of the data, approved the final manuscript, and is the author responsible for archiving the study files.

**Name:** Young Joo, MD.
**Contribution:** This author helped design the study and conduct the study.

**Attestation:** Young Joo has seen the original study data, reviewed the analysis of the data, approved the final manuscript, and is the author responsible for archiving the study files.

**Name:** Tae-Yun Sung, MD.
**Contribution:** This author helped conduct the study and analyze the data.

**Attestation:** Tae-Yun Sung has seen the original study data, reviewed the analysis of the data, approved the final manuscript, and is the author responsible for archiving the study files.

**Name:** Sung-Yun Kim, MD.
**Contribution:** This author helped conduct the study.

**Attestation:** Sung-Yun Kim has seen the original study data, reviewed the analysis of the data, approved the final manuscript, and is the author responsible for archiving the study files.

**Name:** Hwa-Yong Shin, MD, PhD.
**Contribution:** This author helped design the study and write the manuscript.

**Attestation:** Hwa-Yong Shin has seen the original study data, reviewed the analysis of the data, approved the final manuscript, and is the author responsible for archiving the study files.
The Influence of Aprotinin and Tranexamic Acid on Platelet Function and Postoperative Blood Loss in Cardiac Surgery: Retraction


Reference:
DOI: 10.1213/ANE.0b013e31821a8fd2

A New Plasma-Adapted Hydroxyethylstarch Preparation: In Vitro Coagulation Studies Using Thrombelastography and Whole Blood Aggregometry: Retraction


Reference:
DOI: 10.1213/ANE.0b013e31821a9054