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Evaluation of the Effects of Anesthetics and Surgery on Sleep Quality in Patients Undergoing Posterior Spinal Instrumentation Surgery: A Prospective Randomised Clinical Trial

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ABSTRACT

Introduction: The aim of the study is to evaluate the impact of the anesthesia methods and surgical procedure on the sleep patterns and sleep quality of patients undergoing posterior spinal instrumentation, using the Pittsburgh Insomnia Rating Scale-20 (PIRS-20).

Methods: A total of 40 patients, American Society of Anesthesiology I-III, aged 18 and over who underwent elective spinal posterior instrumentation were included. The patients were divided into two groups randomly-those with sevoflurane-remifentanil anesthesia and those with total intravenous anesthesia-using the closed envelope method. Patients were evaluated before and after surgery for sleep quality using the PIRS-20 one month before surgery and on the 7th day postoperatively, for pain using the Visual Analog Scale (VAS) recorded one night before surgery and the first hour postoperatively, and for anxiety using the State-Trait Anxiety Inventory (STAI) recorded one night before surgery and on the 7th day postoperatively.

Results: When pre-operative and postoperative PIRS-20, VAS, and STAI scores were compared, no significant difference was observed between group T and group S ($p>0.05$). The VAS values in group S and group T decreased significantly over time (group S: $p<0.001$; group T: $p=0.001$, respectively). The STAI scores decreased significantly over time ($p=0.001$). The PIRS-20 values remained unchanged in groups S and T ($p=0.132$, $p=0.828$, respectively).

Conclusion: The results of the study showed that while the type of anesthesia did not affect the quality of sleep in the group of patients receiving posterior instrumentation, the surgical procedure did influence pain reduction in both anesthesia methods.

Keywords: Posterior instrumentation, sleep quality, anesthetics, spine surgery

Introduction

Sleep is necessary to improve learning, memory, and physiological functions, and deterioration of sleep quality harms quality of life. Sleep disorders can also lead to diseases such as cardiovascular disease, diabetes, and cancer. Moreover, sleep quality is associated with life expectancy, especially in older populations (1). Previous research has shown that the quality of sleep for individuals with spinal disorders is lower than that of individuals without spinal disorders. Elderly patients with degenerative lumbar spinal stenosis (LSS) may experience sleep disorders due to pain and poor sleep quality (2). In patients with knee arthritis and other musculoskeletal diseases, sleep quality is often reduced due to diminished joint strength in the resting position. In contrast, patients with LSS have increased pain in positions that significantly narrow the spinal canal, such as sleeping, which causes poor sleep quality (3). Therefore, in patients with LSS, the pain and associated sleep disorders improve after treatment. The surgical treatment of back pain improves the symptoms of post-operative pain and sleep disturbance (4). Postoperative pain and anxiety have also been found to be risk factors associated with postoperative sleep disorders. Post-surgical insomnia can lead to delayed surgical recovery, cognitive dysfunction, increased post-operative sensitivity to pain, and cardiovascular events (5). It is important for healthcare providers to address and manage post-surgical insomnia to optimize patient outcomes.

Anesthetic agents can cause sleep disorders in the postoperative process. Anesthetic drugs interrupt the rhythm of sleep and wakefulness and various biological cycles, such as body temperature and melatonin release, resulting in inadequate sleep and poor sleep quality (6). Total intravenous anesthesia (TIVA) is commonly used in spinal surgery

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because inhalation anesthetics lower the amplitude of motor-stimulated potential, which is a key way to monitor patients during surgery. For propofol-based TIVA, remifentanil is frequently used as an additional medication. The combination of propofol and remifentanil works synergistically to achieve the desired hypnotic-analgesic effect while promoting rapid postoperative recovery. Propofol reduces intraoperative remifentanil requirements, whereas remifentanil facilitates the recovery of consciousness (7). Additionally, it has been suggested that remifentanil may indirectly improve sleep quality by enhancing the effects of propofol.

Steinmetz et al. (8) conducted a study involving 39 infants undergoing cleft lip and palate surgery to evaluate the effects of propofol, remifentanil, and fentanyl-sevoflurane on postoperative sleep disturbances. The findings indicated that while all three anesthetic regimens negatively impacted sleep quality, sevoflurane was associated with fewer postoperative sleep disturbances compared to the propofol-remifentanil combination.

The aim of this study is to evaluate, using the Pittsburgh Insomnia Rating Scale-20 (PIRS-20), the impact of the anesthesia method and surgical procedure on the sleep patterns and sleep quality of patients undergoing posterior spinal instrumentation.

Methods

After obtaining oral and written informed consent and the study was approved by the Clinical Research Ethics Committee of Bursa Uludağ University, Faculty of Medicine (approval no: 2022-12/10, date: 08.06.2022), a total of 40 patients American Society of Anesthesiology I-III, aged 18 and over, who underwent elective spinal posterior instrumentation were included. After obtaining written and oral approvals demographic data were recorded.

The patients were divided randomly into two groups, those with sevoflurane anesthesia and those with TIVA, using the closed envelope method. Patients were evaluated before and after the surgery for sleep quality with the PIRS-20 (one month before surgery and 7th day postoperatively), for pain score with the Visual Analog Scale [(VAS) recorded one night before surgery and first hour postoperatively] and for anxiety score with the State-Trait Anxiety Inventory (STAI) (recorded one night before surgery and 7th day postoperatively).

The anesthesiologist, who recorded all the assessments, was blinded to the patient's anesthesia method. As part of the standard procedure for spinal posterior instrumentation surgery, patients were monitored in the operating room with electrocardiography, invasive or non-invasive blood pressure measurements, peripheral oxygen saturation and capnography. The administered anesthetic and analgesic agents were recorded, along with changes in the patient's blood pressure, including hypotension, and hypertension. All patients were extubated and awakened in the operating room.

The Psychiatric Clinic at the University of Pittsburgh developed the PIRS-20 scale to evaluate people's recent sleep patterns. Overall, the scale consists of 20 items across subjective sleep quality, sleep latency, sleep duration, usual sleep patterns, and sleep disorders. The score is from 0 to 60, with 20 or more points indicating poor sleep quality; the higher the score, the poorer the quality of sleep. PIRS-20 was preferred in our study because it evaluates the level of anxiety or stress-based arousal before falling asleep. Postoperative pain was assessed using the VAS on the preoperative night and the first postoperative hour. A morphine infusion was initiated using patient-controlled analgesia based on the following protocol: a total solution volume of 100 mL with a concentration of 1 mg/mL, a bolus dose of 2 mg, a lockout interval of 15 minutes, no basal infusion, and a maximum dose of 10 mg over 4 hours. In cases of nausea and vomiting, 4 mg ondansetron (Kemoset®, Deva İlaç) was administered IV.

Management of General Anesthesia

After the patients were transferred to the operating room, an 18-gauge peripheral venous cannula was meticulously placed to establish venous access. A 0.9% sodium chloride IV infusion was started at a rate of 10 mL//kg/hour. Throughout the procedure, patients underwent continuous monitoring using pulse oximetry, electrocardiography, and non-invasive or invasive blood pressure measurements, and bispectral index (BIS). Midazolam was administered at a premedication dosage of 0.02 mg/kg. Following preoxygenation, anesthesia was induced with an intravenous injection of Propofol-PF® 1% (POLIFARMA Pharmaceuticals, Tekirdağ, Türkiye) (2 mg/kg), rocuronium (0.6 mg/kg) and fentanyl (2 mcg/kg). After securing the airway with a cuffed endotracheal tube (manufactured by Henan Tuoren Medical Device Ltd., Henan, China), mechanical ventilation was initiated with an inspired oxygen fraction of 50%, and minute ventilation was adjusted to maintain end-tidal carbon dioxide ($EtCO_2$) levels within the range of 35-45 mmHg. Group S received sevoflurane (Sevorane® liquid 100%, AbbVie Pharmaceuticals, İstanbul, Türkiye) for anesthesia maintenance, with an end-tidal sevoflurane concentration set at 1 minimal alveolar concentration. Furthermore, remifentanil (Opiva vial®, Tüm Ekip Pharmaceuticals Inc., İstanbul, Türkiye) was administered IV, at an infusion rate ranging from 0.05 to 0.2 µg kg/minimum (min). Group P received propofol at a dosage of 75-100 µg/kg/min and remifentanil IV at a dosage of 0.05-0.2 µg/kg/min.

The depth of anesthesia was monitored by maintaining BIS readings within the range of 40 to 60. The researchers ensured that the mean arterial pressure remained within a range of 20% of the initial value.

Sample Size Estimation

The primary outcome was the postoperative PIRS-20 score. Results from a previous study 9 determined the number of patients needed for analysis using G* Power 3 (Heinrich-Heine-Universitat Düsseldorf, Germany). The Pittsburgh Sleep Quality index (PSQI) scores in the TIVA groups and inhalation groups were 12.06 (2.18) and 14.03 (1.72), respectively, in the previous study. The sample size was determined using a power of 85% and an alpha of 0.05. It was found that 19 patients in each group, totaling 38 patients, were needed to produce statistically significant results.

Statistical Analysis

The SPSS Version 25.0 was used for statistical analysis. Frequency tables were calculated for categorical variables, and descriptive statistics were calculated for continuous variables. A Pearson chi-square test was used to examine categorical data across groups. The normal distribution of continuous variables was analyzed with the Shapiro-Wilk normality test. When the normal distribution was present, the t-test was used for two independent groups, and when there was no normal distribution, the Mann-Whitney U test was used. When there was no normal distribution, the Friedman test was used to compare measurements taken at different times in independent groups. The significance level was taken as 0.05 in all hypothesis tests.

Results

A total of 40 patients were recruited for posterior spinal instrumentation surgery evaluation, with surgery for two patients briefly canceled. Ultimately, 38 patients were included in the whole study, with 17 in group P and 21 in group S. The consort flow diagram of patients (Figure 1) compares the patients' demographic and physiological characteristics between the two groups.

There were no significant differences between the two groups in terms of age, sex, body mass index, neck thickness, snoring, sleep apnea (witnessed), large tongue, surgical type, surgical level, and presence of decompression ($p>0.05$). The Mallampati scores were significantly different ($p=0.029$) (Table 1).

No significant difference was observed in the pre-operative and postoperative PIRS-20, VAS, and STAI scores between group T and group S ($p>0.05$). The VAS values in group S and group T decreased significantly over time ($p<0.001$, $p=0.001$, respectively). The STAI scores decreased significantly over time ($p=0.001$, $p=0.001$, respectively). The PIRS-20 values remained unchanged in groups S and T ($p=0.132$, $p=0.828$, respectively) (Tables 2-4; Figure 2).

Discussion

The findings of this study indicated that the choice of anesthesia method had no impact on postoperative pain quality, sleep quality, or the incidence of insomnia. However, significant variations in pain and anxiety levels were observed between the preoperative and postoperative periods. Moreover, patients in this study experienced comparable changes in sleep quality both in the month leading up to the surgery and throughout the seven-day postoperative period.

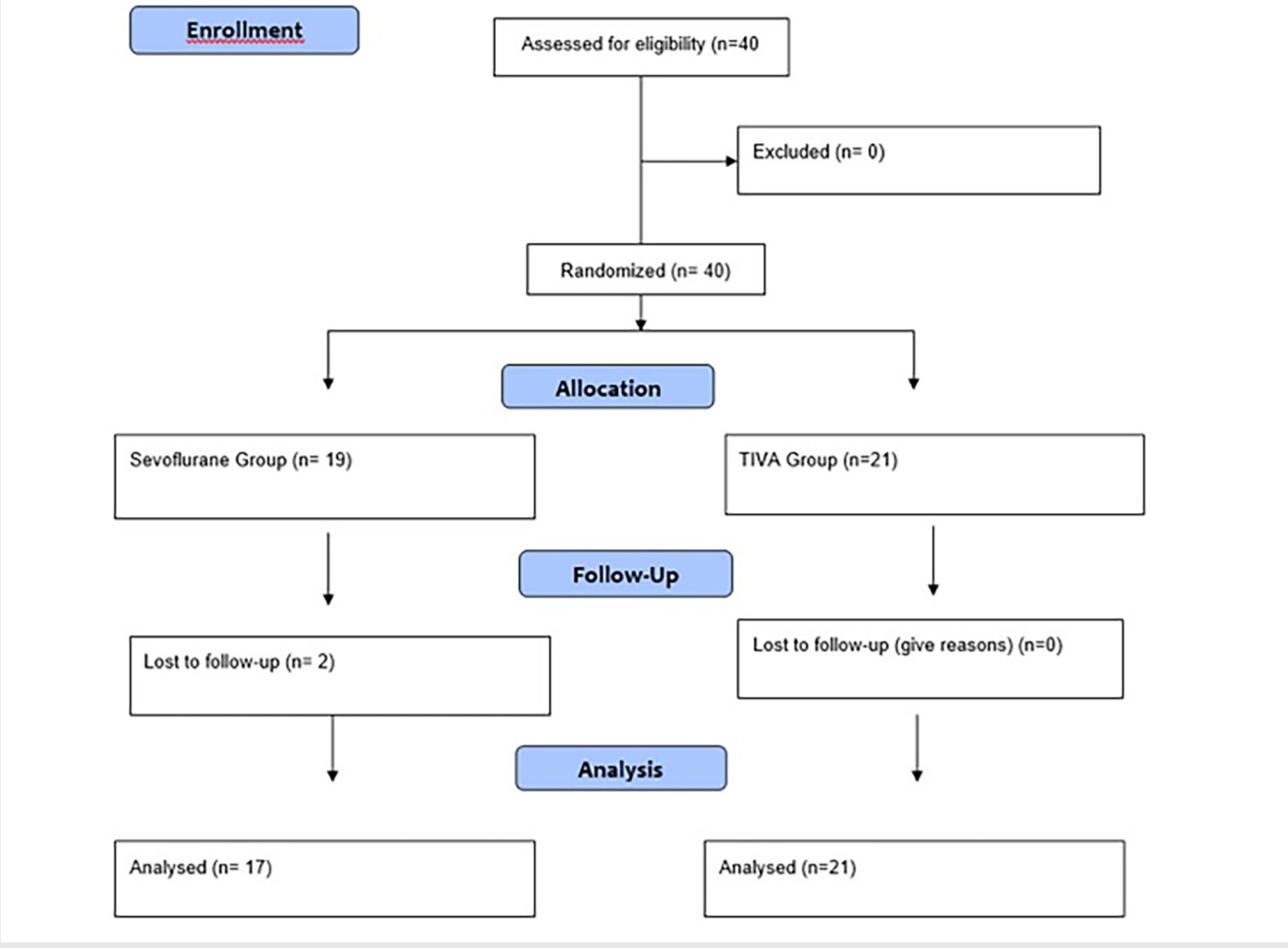

Figure 1. The CONSORT flow diagram of patients

Table 1. Demographic and physiological characteristics data

	Group S (n=17)	Group T (n=21)	p
Age (year)	60.76±10.10	55.471±9.3	0.581
Sex (F/M)	11/6	16/5	0.561
BMI (kg/m^2)	29.14±5.48	27.74±4.84	0.504
ASA score (I/II/III)	2/12/3	5/14/2	0.383
Sleep disorder (Y/N)	6/11	5/16	0.728
Neck (N/T)	5/12	13/8	0.089
Mallampati (I/II/III/IV)	1/9/6/1	6/13/1/1	0.029*
Snoring (Y/N)	11/6	7/14	0.101
Sleep apnea (Y/N)	1/16	1/20	0.954
Large tongue(Y/N)	5/12	5/16	0.772
Surgery (primer/ revision)	14/3	19/2	0.685
Surgery level	16/1/0	10/1/10	0.1
Dekomprestion (Y/N)	15/2	16/5	0.542

*p<0.05 is significantly different, F: Female, M: Male, Y: Yes, N: No, N: Normally, T: Thickness, ASA: American Society of Anesthesiology, BMI: Body mass index

Table 2. VAS scores

	Group S (n=17)	Group T (n=21)	p
PreopVAS	5.88±.65	5.61±2.51	0.136
PostopVAS	1.47±1.28	2.28±1.55	0.101
p	<0.001*	0.001*	

*p<0.05 is significantly different, VAS: Visual Analogue Scale

Table 3. STAI scores

	Group S (n=17)	Group T (n=21)	p
STAI 1	41.05±8.39	41.33±10.57	0.67
STAI 2	30.76±5.25	34.04±8.44	0.41
p	0.001*	0.001*	

*p<0.05 is significantly different, STAI: State-Trait Anxiety Inventory

Table 4. PIRS-20 scores

	Group S (n=17)	Group T (n=21)	p
PIRS-20 1	17.52±12.4	19.38±12.898	0.681
PIRS-20 2	15.11±10.54	18.57±13.02	0.471
p	0.132	0.828	

*p<0.05 is significantly different, PIRS-20: Pittsburgh Insomnia Rating Scale-20

In a study by Lee et al. (10), 63.5% of patients with symptomatic LSS experienced poor sleep quality, and other reports have linked inadequate sleep quality to certain musculoskeletal conditions. People who suffer from chronic low back pain are more likely to report getting little sleep, according to research by Marty et al. (11). Although sleep disturbances have become increasingly common, it remains unclear whether LSS is the primary underlying cause of this issue. Nevertheless, given the much higher incidence of neuropathic pain in the group of poor sleepers, neuropathic pain may mediate the relationship between LSS and sleep disturbance (11). This finding aligns with previous studies

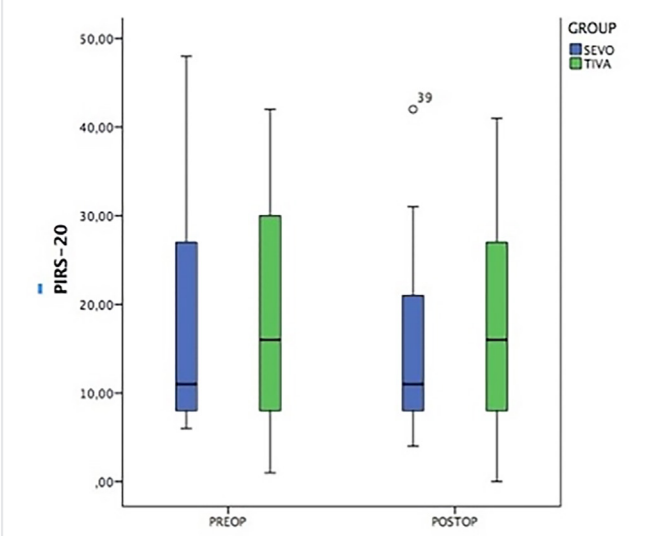

Figure 2. Comparison of PIRS-20 score according to groups

demonstrating a correlation between neuropathic pain and sleep disturbances. Furthermore, the improvement in sleep quality following surgery provides additional insight into the relationship between LSS and impaired sleep (12).

Kim et al. (13) found that treating LSS patients surgically or conservatively improved their sleep quality, as measured by the patients' PSQI. Surgery led to faster sleep quality improvement, and the surgical group experienced lower insomnia, sleep disorder, and daytime dysfunction than the conservative treatment group. In addition, patients in the surgical group showed a continuous improvement in their quality of sleep after surgery. This study showed a significant improvement in pain scores and quality of sleep after surgical treatment. The type of anesthetic used appears to have an impact on the incidence of postoperative pain.

In a study by Meng et al. (14), the pain and quality recovery scores of groups receiving TIVA and Sevoflurane were compared. The results showed that the sevoflurane group had higher VAS values, but the TIVA group had a superior quality of recovery. Propofol is a frequently used IV anesthetic medication for both starting and maintaining general anesthesia. An improved wake-up experience and less nausea and vomiting are two of the many advantages of using TIVA with propofol (15). Propofol can ease pain and has been shown in animal studies to lower levels of cytokines that cause inflammation and prevent N-methyl-D-aspartate (NMDA) receptors from activating (16,17). Clinical trials comparing propofol to inhalational anesthesia demonstrated that propofol offered superior results, and pain levels decreased during the 24 hours following surgical procedures (18). In addition, the use of TIVA in combination with propofol may decrease the occurrence of chronic postsurgical pain (19). Nevertheless, other clinical investigations have shown no superior analgesic efficacy following surgical intervention with propofol. The efficacy of propofol as an analgesic may vary depending on surgical procedures, as the severity and mechanism of pain are likely to change across various types of surgeries, which aligns with the notion of intervention-specific analgesia (20,21). Additionally, the

administration of propofol has been found to mitigate the hyperalgesic effects induced by remifentanil infusion.

One important matter is how propofol blocks NMDA receptors, which are involved in the pathways through which remifentanil provides analgesia (16). In our study, there was no difference between the postoperative pain values for the inhalation group and the TIVA group. Our patients likely experienced high levels of preoperative pain due to spinal stenosis, and the postoperative reduction in pain may explain the lack of distinction between anesthesia methods. Hu et al. (22) conducted a study using the PSQI to assess sleep quality following a laparoscopic gynecologic procedure in females with insomnia who were under TIVA anesthesia. This study had the potential to assess the effect of gender and surgical methods on the quality of sleep following surgery. However, the study found a statistically significant improvement in sleep quality in patients who underwent TIVA anesthesia compared to sevoflurane anesthesia. Another study found that sevoflurane has a less enduring effect on sleep quality than propofol (8).

However, Ma et al. (23) presented a different perspective. The PSQI uses a threshold of 6 points to indicate the presence of sleep problems. As the PSQI score increases, sleep quality declines. Ma et al. (23) study found that the PSQI scores at 24 and 48 hours post-surgery were greater than 6 and higher than the pre-surgery values in both groups, showing the presence of postoperative sleep disturbances. Nevertheless, no significant difference was reported between the TIVA and inhalation groups. This study showed that the quality of sleep before and after surgery was different for all patients. However, comparing the methods of anesthesia, the PIRS-20 scores were similar between the TIVA and inhalation groups, and there was no significant difference in sleep quality.

Study Limitations

The present study was carried out in a group of patients whose low sleep quality was due to pain and in whom surgery could make a significant difference. It can pose a problem in investigating the difference between anesthetic agents and can be regarded as a limitation of the study. On the other hand, it is important to investigate the effect of different anesthetic agents on sleep quality in patients with preoperative insomnia. One of the significant limitations of our study is that all patients had pain, and it is not known whether there was any sleep disorder before the onset of pain. The lack of a control group without pain is a deficiency. However, since surgical intervention is not applied to spine pathologies without pain, the possibility of surgical treatment is not considered.

Conclusion

The results of the current study showed that while the type of anesthesia did not affect the quality of sleep in patients receiving posterior instrumentation, the surgical procedure affect pain reduction in both anesthesia methods.

Ethics

Ethics Committee Approval: The study was approved by the Clinical Research Ethics Committee of Bursa Uludağ University, Faculty of Medicine (approval no: 2022-12/10, date: 08.06.2022).

Informed Consent: Written informed consent was obtained from all participants.

Footnotes

Authorship Contributions: Surgical and Medical Practices - S.A., G.E.; Concept - S.A.; Design - S.A.; Data Collection or Processing - S.A., G.E.; Analysis or Interpretation – S.A.; Literature Search - S.A., G.E., Y.B., S.B.G., E.U.; Writing – S.A., G.E., Y.B., S.B.G., E.U.

Conflict of Interest: No conflict of interest was declared by the authors.

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