Observational Study

Pre-Emptive and Multi-Modal Perioperative Pain Management May Improve Quality of Life in Patients Undergoing Spinal Surgery

Byung Ho Lee, MD[1], Jin-Oh Park, MD[3], Kyung-Soo Suk, MD[3], Tae-Hwan Kim, MD[1], Hwan-Mo Lee, MD, PhD[1], Moon-Soo Park, MD[1], Seung-Hwan Lee, MD[1], Sangun Park, PhD[2], Ju-Yeon Lee, MA[3], Su-Kyoung Ko, MA[3], Seong-Hwan Moon, MD, PhD[1]

From: [1]Department of Orthopaedic Surgery, Yonsei University College of Medicine; [2]Department of Applied Statistics, School of Business, Yonsei University; [3]Market Assess Pfizer Pharmaceutical Korea Limited

Address Correspondence:
Seong-Hwan Moon, MD, PhD
Professor
Department of Orthopaedic Surgery
Yonsei University College of Medicine
#50 Yonseiro, Seodaemunku
Seoul, Korea
E-mail: shmoon@yuhs.ac

Disclaimer: Survey and study design originally sponsored by Pfizer medical reserach team. Conflict of interest: None.

Manuscript received: 12-25-2012
Revised manuscript received: 02-19-2013
Accepted for publication: 02-28-2013

Free full manuscript: www.painphysicianjournal.com

Background: Compared to an abundance of data on surgical techniques for degenerative spine conditions and the outcomes thereof, little is available to guide optimal perioperative pain management after spinal surgery. The aim of this study was to survey patterns of perioperative pain management after spinal surgery and to investigate the effects of perioperative pain management, such as pre-emptive analgesia and multi-modal postoperative pain management, on acute postoperative satisfaction, pain reduction, and health-related quality of life in patients undergoing spinal surgery.

Study design: Non-blind multicenter prospective observational clinical series.

Setting: Seventeen tertiary hospitals (14 hospitals attached to medical colleges and 3 general hospitals).

Methods: Pain management protocols of 393 patients (153 men, 240 women; mean age of 67 years, ranging from 21 to 91 years) from 17 tertiary hospitals after spinal surgery for degenerative spine disease were evaluated using a self-administered questionnaire.

Results: A total of 79 (20%) patients received pre-emptive analgesics, which included cyclooxygenase-2 (COX-2) inhibitors, with or without administration of anticonvulsants, immediately before surgery at the time of antibiotic prophylaxis. Postoperative pain was managed mainly by multi-modal therapy (363 cases, 92%), along with various combinations of patient controlled anesthesia (PCA), conventional nonsteroidal anti-inflammatory drugs (NSAIDs), COX-2 inhibitors, and narcotics. Self-reported levels of pain were not significantly different among postoperative multiple modalities of pain management, but were different significantly for pre-emptive pain management regimens ($P < 0.05$, independent t-test). The number of patients that reported the self-administrative use of PCA was higher in the no pre-emptive pain management group compared to the pre-emptive group ($P < 0.05$). In regards to EQ-5D usual activity, depression/anxiety and self-care improved significantly in the pre-emptive pain management group when measured at 2 weeks postoperative ($P < 0.05$).

Limitations: The limitation of our study is that it is not a randomized controlled observational study.

Conclusions: Pre-emptive analgesia and multi-modal pain management after spinal surgery may lead to better health-related quality of life, greater patient satisfaction, and less postoperative pain.

Key words: Degenerative spine, surgery, pre-emptive, pain, management

Pain Physician 2013; 16:E217-E226

Spinal surgery for degenerative conditions can improve clinical outcomes, including quality of life parameters such as cost/quality-adjusted-life-years (cost/QALY) and life expectancy in surgically treated patients (1-6). As the global population continues to age, spinal surgery is being performed with an increasing frequency for consequent degenerative conditions of the spine, such as intervertebral disc herniation, spinal stenosis, spondylolisthesis, and degenerative kypho-scoliosis (7). Despite an abundance of data on surgical techniques and the outcomes thereof, little is available to guide optimal perioperative pain management after spinal surgery (8).

Perioperative pain management is crucial to improving postoperative quality of life and for decreasing pain-related morbidity. Conventional decompression and fusion surgery for degenerative spine conditions demands postoperative transfusion and multi-modal pain management, including patient-controlled anesthesia (PCA), intra-lesional anesthesia, and oral and intravenous postoperative analgesic medications (9,10). Perioperative pain control is an emerging concept. Pre-emptive analgesia has been shown to increase pain thresholds during the perioperative period, which helps patients to better tolerate pain, and reduces postoperative narcotic use (11-13). Fine-tuned perioperative pain management might improve patient satisfaction by decreasing pain perception and morbidity, quickly restoring quality of life and reducing medical costs (13-15). Perioperative pain management requires a multifaceted strategy that considers the following factors: 1) timing, including before and after surgery; 2) targeting the central and peripheral pain pathways; 3) route of administration, such as oral, intravenous, intramuscular, or intra-lesional; and 4) local containment of side effects and reduction of systemic effects, such as postoperative bleeding, drowsiness, and gastrointestinal problems.

Notwithstanding, systematic research is needed to develop a standardized protocol that provides an optimal strategy for carrying out perioperative pain management. Nevertheless, the actual practice of perioperative pain management following major spinal fusion surgery has not been fully surveyed or documented. To develop a standardized protocol for postoperative pain management, further study of clinically controllable factors, such as pre-emptive analgesia and multimodal postoperative pain management, is needed. Therefore, the purposes of the current prospective, multicenter, observational study were to survey patterns of perioperative pain management after spinal surgery and to investigate the effects of perioperative pain management, such as pre-emptive analgesia and multi-modal postoperative pain management, on acute postoperative patient satisfaction, pain reduction, and health-related quality of life in patients undergoing spinal surgery.

Methods

All experimental protocols involving patients were approved by the Institutional Review Board of each participating institution (IRB No. 2011-0671).

Patients

From January 2011 to June 2011, patients who underwent instrumented lumbar spinal fusion with or without laminectomy for various degenerative conditions, such as intervertebral disc herniation, spinal stenosis, degenerative spondylolisthesis, and degenerative lumbar scoliosis, were included in our study. Exclusion criteria were high-energy spinal fracture (21 patients), post-spinal surgery syndrome (40 patients), metastatic spine disease (12 patients), infection (7 patients), significant medical problems either prior to surgery or during the study period (such as angina pectoris, myocardial infarction, and cerebrovascular disease with sequelae), and Parkinson's disease (6 patients). After excluding patients who did not meet the inclusion criteria, 393 patients (153 men, 240 women; mean age of 67 years, ranging from 21 to 91) were finally enrolled in the study (Fig. 1).

Assessments

We evaluated the pain management protocols of 17 tertiary hospitals (14 hospitals attached to medical colleges and 3 general hospitals) carried out by 19 different spine surgeons for spinal fusion patients, using a self-administered questionnaire. As a spine surgeon may employ different pain management methods in individual patients, the questionnaire was designed to be completed by all of the enrolled patients. The questionnaire was mainly designed to evaluate the practice patterns of preoperative and postoperative pain management, routine patient education about pain after spinal surgery, and pre-emptive analgesia, as well as types of drugs used. The evaluation of patients who underwent spinal fusion surgery was prospectively carried out using a self-administered questionnaire under the supervision of clinical research coordinators (CRC). CRCs were trained to evaluate patients in a standardized manner.

When an enrolled patient was admitted to the hospital, a CRC visited the patient the day before surgery and explained how to fill out the self-administered questionnaire. After spinal fusion surgery, CRCs regularly visited the patients to collect the questionnaires, subsequently entering the results into a database. CRCs were trained not to affect the patients' decision, but were allowed to provide explanations to patients who had difficulty completing the questionnaire. CRCs were also blinded to the preoperative data, so as not to bias the data for the postoperative questionnaire.

Pain levels were estimated by patients using a specially designed pain diary on a visual analog scale (VAS) ranging from 0 (no pain) to 100 (worst imaginable pain). Pain levels were assessed on the night after the operation and also at one, 2, 3, 7, and 14 days postoperatively. Quality of life was evaluated using the EQ-5D-5L on the day before surgery, postoperative day (POD) 14, and 3 months after surgery (Table 1).

The EQ-5D consisted of the EQ-5D descriptive system and the EQ visual analogue scale (EQ VAS), and could be used to evaluate surgical outcomes of spine surgery (5). The EQ-5D descriptive system comprised the following 5 dimensions: mobility, self-care, usual activities, pain/discomfort, and anxiety/depression. Each dimension had 3 levels: no problem was scored as one, some problems were scored as 2, and severe problems were scored as 3. The EQ VAS was designed to assess patients' self-rated health on a VAS, which ranged from 0 (worst imaginable health state) to 100 (best imaginable health state). All evaluations and time points are listed in Table 1. Each evaluation was compared and analyzed statistically.

The standard dosage of Fentanyl based patient controlled anesthesia (PCA) (1500 mcg in 30 mL) was a 10 mcg/h basal rate. The administration of an additional 25 mcg maximal bolus at 15 minute intervals was permitted based on patient need. A total administered dose of PCA was limited to 800 mcg for 4 hours.

Data Analysis

To compare repeated measures of VAS and EQ-5D between the patient groups, we employed a linear mixed model. This model included a mixture of fixed and random effects, where fixed effects included population averages of patient groups, times, and the patient group by time interaction, while random effects were those that varied across patients. We inter-

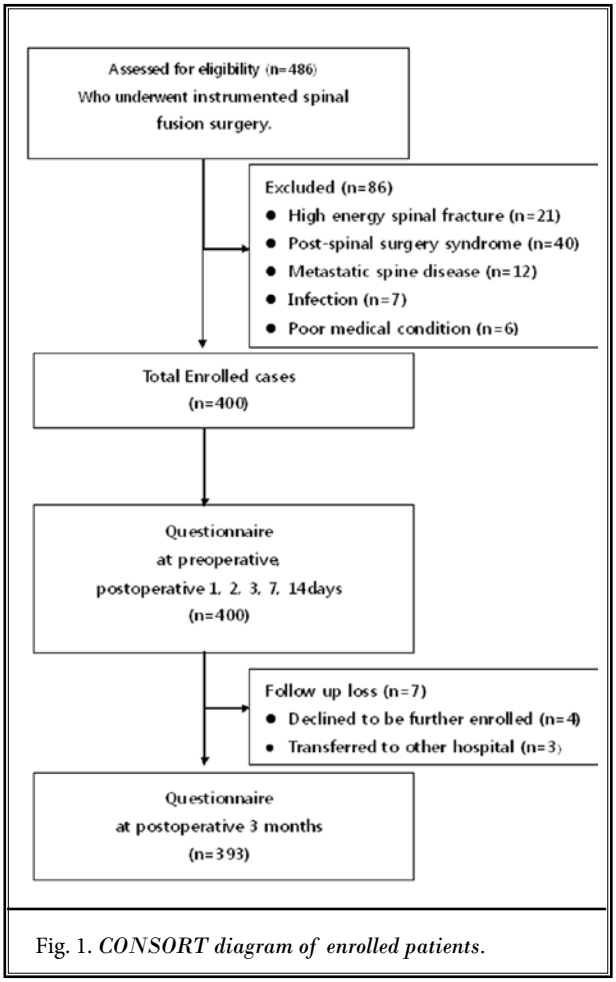

Fig. 1. *CONSORT diagram of enrolled patients.*

Table 1. Time points for patient assessment.

	Preop	Op Day	During Admission	2 Weeks	1st POD Visit	3 Months
Demographics	O					
Surgery profile		O				
Pain management regimen	O	O	O	O		
EQ-5D	O			O		O
Pain diary (VAS)	O	O	O	O		O

preted the statistical results mainly in terms of patient group effects and linear time effects at a significance level of 0.05. Multiple regression analysis was used to evaluate the correlating factors affecting the use of PCA and reduction in postoperative VAS. All collected data were analyzed using the Statistical Package for the Social Sciences (SPSS) version 12.0.1 (SPSS, Inc., Chicago, IL, USA).

Table 2. *Patient Characteristics*.

	Patients (%)
Gender	
Male	153 (39)
Female	240 (61)
Diagnosis	
Spinal stenosis	311 (79)
Degenerative spondylolisthesis	38 (10)
Intervertebral disc herniation	10 (3)
Degenerative lumbar kypho-scoliosis	9 (2)
Other	25 (6)
Preoperative aspirin use	68 (17)
Endoscopically proven UGI pathology	41 (10)
Preoperative pain management	
NSAIDs with gastroprotective agents	146 (37)
NSAIDs only	97 (25)
Weak opioid	90 (23)
COX-2 inhibitor	31 (8)
Opioids	29 (7)
Preemptive analgesia	79 (20)
Surgical procedures	
PLF	222 (56)
PLIF	133 (34)
Other (decompressive laminectomy and/or discectomy)	38 (9)
Level of surgery	
1 level	171 (44)
2 or more levels	222 (56)
Postoperative pain management	
Single therapy	30 (8)
Multi-modal therapy	363 (92)

UGI: upper gastrointestinal, NSAID: nonsteroidal anti-inflammatory agent, COX-2: cyclooxygenase-2, PLF: posterolateral fusion, PLIF: posterior lumbar interbody fusion.

Results

Practice Patterns

Two hundred and forty (61%) women and 153 (39%) men who underwent spinal surgery participated in the study. Sixty-eight patients (17%) took aspirin preoperatively. Forty-one patients (10%) had clinically or endoscopically diagnosed gastrointestinal conditions, including gastritis, peptic ulcer, and gastro-esophageal reflux disease. Preoperative pain management included nonsteroidal anti-inflammatory drugs (NSAIDs) in 97 patients (25%), NSAIDs with a gastroprotective agent in 146 patients (37%), cyclooxygenase-2 (COX-2) inhibitors in 31 patients (8%), weak opioids such as tramadol or a tramadol + acetaminophen combination in 90 patients (23%), and opioids in 29 patients (7%) (Table 2).

All patients received preoperative education on the surgical procedure, expected clinical results, possible complications, and postoperative pain management. Only 20% of the patients received pre-emptive analgesics, which included a COX-2 inhibitor (Celecoxib) with or without anticonvulsants (e.g., gabapentin, dose 600 mg) administered immediately before surgery at the time of antibiotic prophylaxis. Surgical procedures included postero-lateral fusion (PLF) with or without instrumentation (222 procedures, 56%) and posterior interbody fusion (PLIF) with instrumentation (133 procedures, 34%), among 171 cases (44%) of single level surgery and 222 (56%) of multi-level surgery (Table 2). Postoperative pain was managed mainly by multi-modal therapy (363 cases, 92%) with various combinations of PCA, conventional NSAIDs, COX-2 inhibitors, and narcotics. Only 30 cases received a single regimen for postoperative pain management.

Patient Pain Experience

Self-reported levels of pain on the VAS (mm) were 69.2 ± 23.6 (mean ± standard deviation) on preoperative evaluation, 80.4 ± 18.8 on the day of surgery, 71.7 ± 20.9 on POD 1, 64.0 ± 20.9 on POD 2, 55.9 ± 21.2 on POD 3, 43.7 ± 20.9 on POD 7, and 31.1 ± 19.4 on POD 14, and demonstrated a significant time-dependent decrease on PODs 3, 7, and 14 ($P < 0.001$, linear mixed model).

Self-reported pain VAS scores in the pre-emptive and the non-pre-emptive groups were 77.0 ± 19.5 and 81.4 ± 17.3 on operation day, 65.6 ± 23.3 and 73.5 ±18.8 on POD 1, 55.2 ± 22.5 and 67.6 ± 18.1 on POD 2, 48.4 ± 21.2 and 59.2 ± 18.9 on POD 3, 38.9 ± 21.8 and 45.7 ± 19.0 on POD 7, and lastly, 26.8 ± 17.3 and 32.6 ± 19.0 on POD 14.

Self-reported pain VAS scores in the single and multiple modality management groups were 80.2 ±

18.8 and 81.9 ± 13.7 on operation day, 70.9 ± 21.1 and 73.9 ± 17.4 on POD 1, 63.9 ± 21.3 and 67.9 ± 15.4 on POD 2, 56.3 ± 20.6 and 60.1 ± 17.9 on POD 3, 45.3 ± 21.2 and 43.2 ± 15.4 on POD 7, and 33.4 ± 19.3 and 25.6 ± 16.7 on POD 14 (Fig. 2 and 3).

Self-reported levels of pain were not significantly

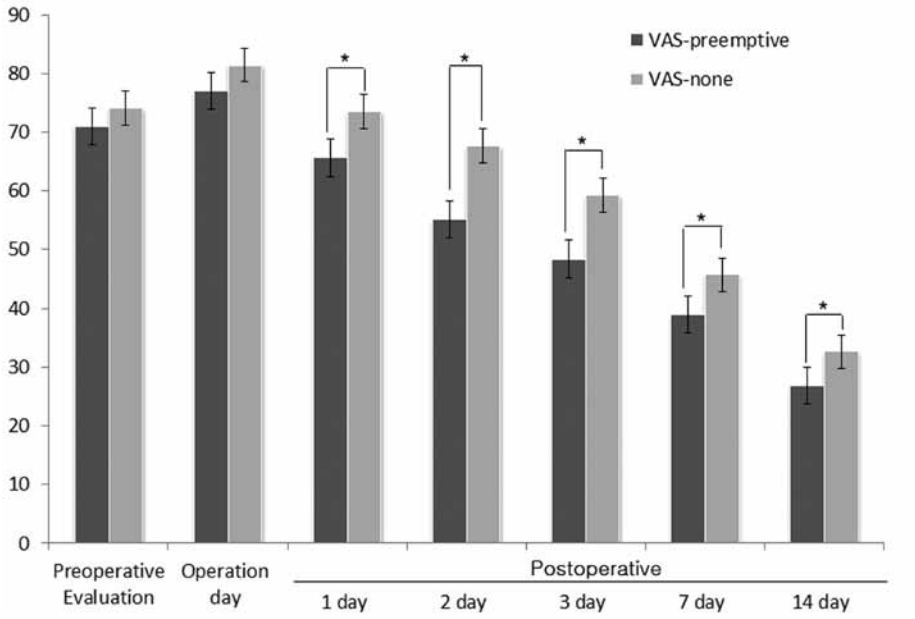

Fig. 2. *A significant, time-dependent reduction in pain VAS scores was noted after surgery from operation day until POD 14 ($P < 0.05$). A significant difference in the average pain VAS score between the pre-emptive pain control group and the no pre-emptive pain control group was observed on POD one to POD 14 ($P < 0.05$) There was also an interaction between time and pre-emptive pain management; the average VAS of the pre-emptive pain control group decreased faster than that of the no pre-emptive pain control group (Mean ± Standard error of mean).*

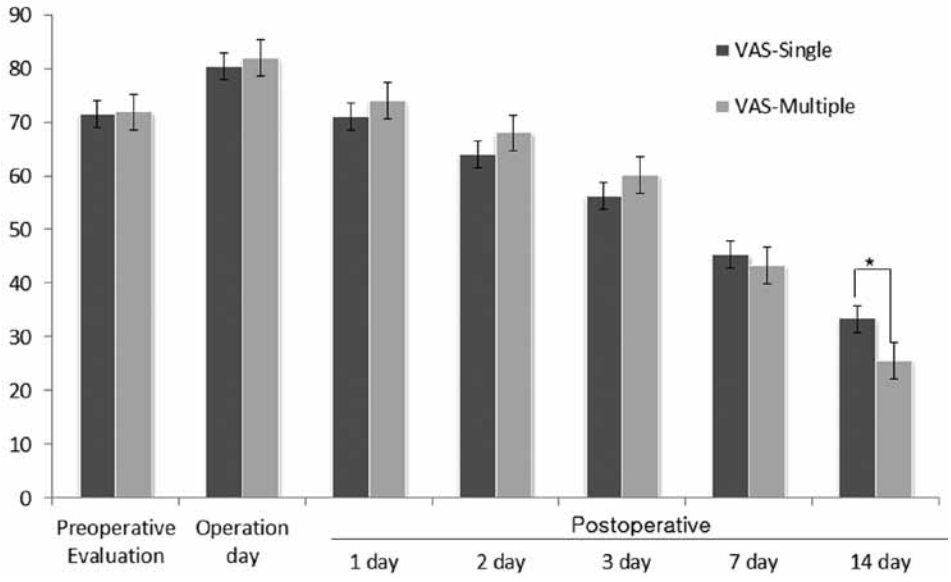

Fig. 3. *There was a significant difference in the average pain VAS score between the single modality pain control group and the multi-modality pain control group only on POD 14 ($P < 0.05$) (Mean ± Standard error of mean).*

different among postoperative multiple modalities of pain management except on POD 14, but were different significantly for pre-emptive pain management regimens on postoperative measures ($P < 0.05$, independent t-test).

Separate linear-mixed model analyses for each of the following variates of gender, age, level of surgery, surgical procedures, pre-emptive analgesia, and multimodality of postoperative pain management showed that men, pre-emptive analgesia, and multi-modal postoperative pain management were significantly associated with a reduction in postoperative VAS compared to the corresponding factors of women, receiving no pre-emptive analgesia, and being administered a single regimen for postoperative pain management ($P < 0.05$, linear mixed model). Age, level of surgery (one vs multiple levels), and surgical procedure (PLF vs PLIF) did not significantly affect changes in postoperative VAS.

PCA Use

After surgery PCA was used 6.7 ± 5.7 times (mean ± standard deviation) on the day of surgery, 6.2 ± 6.8 times on POD 1, 5.0 ± 6.3 times on POD 2, and 1.5 ± 2.1 times on POD 3. PCA was discontinued after 3.6 ± 1.8 days postoperatively.

Self-administered PCA use (unit : time) in the pre-emptive and the non-pre-emptive groups were, respectively, 4.6 ± 2.6 and 7.4 ± 6.3 on operation day, 4.1 ± 2.8 and 6.9 ± 7.5 on POD 1, 2.5 ± 1.6 and 6.0 ± 7.1 on POD 2, and 1.5 ± 1.7 and 1.4 ± 2.3 on POD 3. PCA was removed after 3.8 ± 1.6 days in the pre-emptive group and 3.5 ± 1.9 days in the non-pre-emptive group (Fig. 4).

Self-administrative use of PCA was significantly different depending on the pre-emptive pain management received ($P < 0.05$, independent t-test).

The use of PCA on the day of surgery was higher in women patients, as well as in those who received opioids preoperatively, those that had a higher pain VAS on the operation day, and those that received no pre-emptive medication ($P < 0.05$, multiple regression). The use of PCA on POD 1 was also higher in patients that received multiple pain medications preoperatively, as well as in those with a higher pain VAS on POD 1 and in those that more frequently used PCA on the day of the operation ($P < 0.05$, multiple regression). On POD 2, the use of PCA increased and patients reported higher pain VAS ($P < 0.05$, multiple regression). Time to PCA discontinuation was not affected by any of the aforementioned factors.

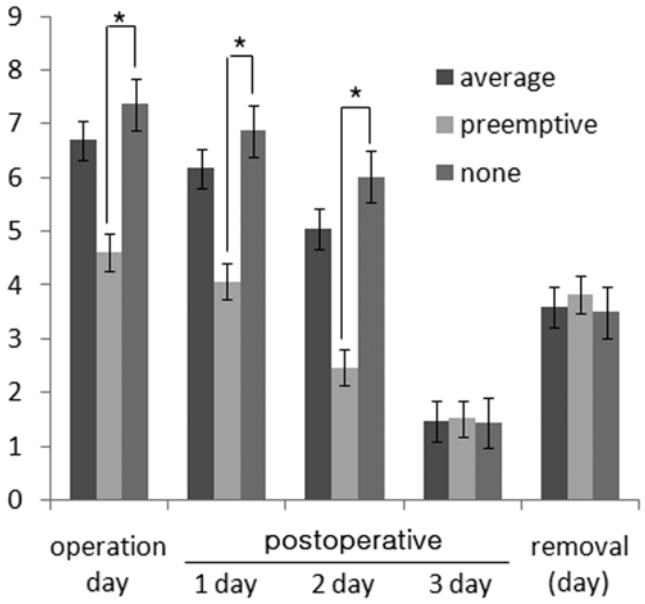

Fig. 4. *The average use per day of PCA (unit : time) between the pre-emptive pain control group and the no pre-emptive pain control group differed significantly from the operation day until POD day 2 ($P < 0.05$). There was no difference in the time to PCA discontinuation according to the pre-emptive pain treatment modality ($P > 0.05$) (Mean ± Standard error of mean).*

Table 3. EQ-5D comparison depending on pain management regimen.

	Preemptive (n=79)	Non-preemptive (n=314)	Significance	Multiple (n= 363)	Single (n=30)	Significance
Preoperative						
Mobility	2.2±0.5	2.0±0.5	-	2.0±0.5	2.1±0.6	-
Self-care	2.1±0.6	1.7±0.6	p<0.05	1.7±0.6	1.9±0.7	p<0.05
Usual activities	2.2±0.6	2.0±0.6	p<0.05	2.0±0.5	2.2±0.6	-
Pain/discomfort	2.3±0.5	2.4±0.5	-	2.4±0.5	2.4±0.5	-
Anxiety/depression	2.1±0.6	1.7±0.6	p<0.05	1.8±0.6	1.9±0.7	-
EQ-VAS	56.8±22.9	59.5±19.4	p<0.05	60.5±19.3	54.9±21.2	p<0.05
Postoperative : week 2						
Mobility	1.7±0.5	1.7±0.9	-	1.7±0.5	1.8±1.2	-
Self-care	1.4±0.5	1.6±0.6	p<0.05	1.6±0.6	1.6±0.6	-
Usual activities	1.5±0.5	1.8±0.5	p<0.05	1.7±0.6	1.7±0.6	-
Pain/discomfort	1.8±0.5	1.8±0.5	-	1.7±0.5	1.9±0.4	p<0.05
Anxiety/depression	1.2±0.5	1.5±0.4	p<0.05	1.2±0.4	1.3±0.5	p<0.05
EQ-VAS	74.8±13.5	71.2±15.3	p<0.05	72.3±14.6	72.5±15.4	-
Postoperative : month 3						
Mobility	1.3±0.6	1.7±0.6	-	1.5±0.5	1.7±0.7	-
Self-care	1.3±0.5	1.5±0.6	-	1.5±0.5	1.4±0.6	-
Usual activities	1.3±0.5	1.7±0.5	p<0.05	1.5±0.5	1.7±0.6	-
Pain/discomfort	1.7±0.5	1.9±0.6	-	1.8±0.5	2.1±0.5	-
Anxiety/depression	1.2±0.5	1.4±0.5	-	1.3±0.5	1.4±0.5	-
EQ-VAS	72.4±13.2	73.8±12.8	-	73.5±14.5	71.2±13.8	-

Changes in Patients' Quality of Life

Scores for all items on the EQ-5D significantly improved 2 weeks and 3 months after surgery compared to their preoperative measures, including the dimensions of mobility, self-care, usual activities, pain/discomfort, and anxiety/depression ($P < 0.05$, repeated measures analysis of variance [ANOVA]). Among the 5 dimensions, usual activity, depression/anxiety, and self care improved significantly in the pre-emptive pain management group at postoperative week 2, compared to the no pre-emptive group ($P < 0.05$, independent t test) (Table 3). Pain/discomfort and anxiety/depression also improved in the multi-modality pain management group at postoperative week 2 ($P < 0.05$, independent t test).

Statistical analysis showed that quality of life was significantly improved 2 weeks and 3 months after spinal surgery for all patients. A younger age was significantly related with improved quality of life, especially in the mobility and pain/discomfort dimensions ($P < 0.05$, linear mixed model). Pre-emptive analgesia, level of surgery, and surgical procedures (PLF vs PLIF) demonstrated a significant interaction effect with time, which indicated that the difference in quality of life between each patient group was dependent on time.

Change in Health Status

Current health status, as measured on a scale of 0 – 100 mm (100 = perfect health status and 0 = worst health status), was 59.6 ± 19.9 mm preoperatively and increased significantly to 71.9 ± 14.7 mm 2 weeks after surgery and to 73.5 ± 13.8 mm 3 months after the operation ($P < 0.05$, repeated measures ANOVA). Men demonstrated a significantly greater increase in current health status compared to women ($P < 0.05$).

Pre-emptive analgesia and PLF demonstrated a significant interaction effect with time, which means that as time passed by, better results were obtained for change in health status compared with non-pre-emptive analgesia and PLIF ($P<0.05$, linear mixed model). Mean current health measures were 57.0 mm in the PLF group and 59.9 mm in the PLIF group preoperatively, 75.8 mm

in the PLF group and 69.4 mm in the PLIF group at postoperative 2 weeks, and 76.6 mm in the PLF group and 69.2 mm in the PLIF group at postoperative 3 months.

Discussion

Measuring the clinical outcomes of spinal surgery requires regular patient follow-up with radiographic examination and functional scores (Oswestry disability index, SF-36, EQ-5D, etc.) (1,3). To verify the effectiveness of surgery, most researchers try to assess long-term clinical results with at least 2 years of postoperative follow-up (16). Most patients are concerned with postoperative pain and morbidity as well as long-term clinical results related to surgical procedures. Therefore, well-coordinated postoperative and/or perioperative pain management is necessary to increase patient satisfaction with surgical procedures and, possibly, their long-term clinical results. In addition, medical costs related to surgical procedures are another key issue for health care planners, providers, and patients. Accordingly, well-coordinated postoperative and/or perioperative pain management have been shown to reduce hospital stays and consequent medical costs related to surgery (14,15).

However, few have reported on acute postoperative pain and changes in quality of life after major spinal surgery. Furthermore, there is no consensus among leading spinal surgeons for the optimal management of postoperative pain after major spinal surgery. Currently, with the help of an anesthesiologist, each surgeon provides postoperative pain management depending on his or her own experience and general principles of pain management. The current, prospective multi-center survey was conducted to assess the current practice patterns of perioperative pain management by spine surgeons, as well as patient satisfaction, change in pain perception over time (VAS), and quality of life (EQ-5D) during the perioperative period after major spinal surgery.

Almost all patients received a certain form of analgesic medication before surgery to ameliorate pain from degenerative spine conditions. Most spine surgeons provided thorough preoperative explanations and education, as well as multi-modal postoperative pain management, but they were reluctant to use pre-emptive analgesia, which was administered to only 20% of the patients.

Health-related quality of life as measured by the EQ-5D uniformly increased rapidly until 2 weeks after surgery, and was sustained at a similar level up to 3 months after surgery. These findings indicated that intensive pain management during the acute postoperative period is necessary. VAS for pain decreased until 3 months after surgery.

In our subgroup analysis, improvements in quality of life were strongly correlated with a younger age (< 70 years old), single-level fusion surgery, multi-modal postoperative pain management, and pre-emptive analgesia. In our analysis of calculated EQ-5D scores, younger age, pre-emptive analgesia, single level surgery, and PLF were associated with significantly improved quality of life until 3 months postoperatively. As expected, older patients, those who underwent multilevel surgery, and patients with PLIF exhibited a relatively smaller increase in quality of life compared with their counterparts. Current health status also improved for 3 months after surgery. In our subgroup analysis of current health status, men, PLF, and pre-emptive analgesia showed a significant increase in quality of life compared to women, PLIF, and no pre-emptive analgesia.

The current study results suggested that pre-emptive analgesia might provide efficient postoperative pain control. There was no significant difference in pain VAS score on operation day between the pre-emptive and the no pre-emptive group. But from POD 1, there was a significant difference in pain VAS score between the 2 groups (Fig. 2). Also, patients in the no pre-emptive group used PCA more frequently to compensate for the lack of pre-emptive pain management (Fig.4), and they also reported feeling more anxious and depressed at postoperative 2 weeks (Table 3).

The multi-modal pain management group fared slight worse in early postoperative pain VAS, but reported better EQ-5D scores for pain/discomfort and anxiety/depression at postoperative 2 weeks. However, this finding warrants careful interpretation. As this was not a randomized, controlled study, patients could move freely from the single regimen group to the multi-modal regimen group if they felt the need to have more pain medication.

In the current study, only 2 factors to reduce postoperative pain could be controlled by the surgeons: pre-emptive analgesia and multi-modal postoperative pain management. Therefore, we recommend that spinal surgeons adopt both analgesic strategies for better postoperative pain control. Other factors that could not be managed by spinal surgeons (such as the gender and age of patients and level of surgery) in reducing postoperative pain could be dealt with by providing patients with a thorough preoperative explanation of

patterns and courses in which postoperative pain and quality of life change. Unexpected, severe postoperative pain might increase patient morbidity and affect the clinical results of the spinal surgery. Thus, to ensure both patient satisfaction and self-assurance during postoperative recovery, it is important to carefully and thoroughly explain patterns of postoperative pain change.

Pre-emptive analgesia has been shown to reduce postoperative pain, narcotic use, and length of hospital stay, and also to improve the quality of life of patients (11,14,15); however, this remains controversial (6,8). The main principle of pre-emptive analgesia is to administer various agents before surgery to modulate postoperative pain by shifting the pain curve or increasing the pain threshold (12,13). Anti-epileptics, such as gabapentin, can be used for pre-emptive analgesia; nevertheless, its clinical outcomes are controversial (17,18). NSAIDs and COX-2 inhibitors may also be an option for pre-emptive analgesia (19,20). However, a consensus has yet to be reached for an ideal regimen of pre-emptive analgesia for spinal surgery (8). A well-controlled clinical trial will be required to identify an ideal combination of drugs for pre-emptive analgesia in spinal surgery patients. Since we did not randomize groups of patients to specific interventions for comparison purposes, future studies employing a more detailed and systemized study design are needed to compare the actual rate of pain reduction between patients who receive pre-emptive pain control and those who do not.

Conclusion

In conclusion, pre-emptive analgesia and multimodal pain management for perioperative pain control in spinal surgery may lead to better health-related quality of life for patients, in addition to higher patient satisfaction. Future studies should focus on the development of a standardized protocol for perioperative pain management after spinal surgery as well as the application and validation of such protocol in a clinical setting.

Supplementary. Standardized Questionnaire for Surgeons
1. Patient age
2. Date of birth
3. History of aspirin, anticoagulant use
4. Preoperative gastrointestinal pathology
5. Preoperative pain management
A. NSAID
B. NSAID+gastroprotective agent
C. COX-2 inhibitor
D. Weak opioid
E. Opioid
F. Other
6. Date of admission
7. Date of operation
8. Date of discharge
9. Operative procedure
A. PLF
B. PLIF
C. Other
10. Level of surgery
A. One level
B. Two levels or higher
11. Operative time
12. Anesthesia
13. Preoperative pain education
14. Preemptive analgesia
A. Opioid
B. NSAID
C. COX-2 inhibitor
D. Other
15. Immediate postoperative pain management
A. Epidural analgesia, single injection
B. Epidural analgesia, continuous injection postoperatively
C. Intrathecal drug injection
D. Intravenous patient-controlled anesthesia
16. Subacute postoperative pain management
17. Discharge medication
NSAID: nonsteroidal anti-inflammatory agent, COX-2: cyclooxygenase-2, PLF: posterolateral fusion, PLIF: posterior lumbar interbody fusion

References

1. Glassman SD, Carreon L, Dimar JR. Outcome of lumbar arthrodesis in patients sixty-five years of age or older. Surgical technique. *J Bone Joint Surg Am* 2010; 92:77-84.
2. Kim HJ, Lee HM, Kim HS, Moon ES, Park JO, Lee KJ, Moon SH. Life expectancy after lumbar spine surgery: One- to eleven-year follow-up of 1015 patients. *Spine (Phila Pa 1976)* 2008; 33:2116-2121; discussion 2122-2113.
3. Weinstein JN, Tosteson TD, Lurie JD, Tosteson AN, Blood E, Hanscom B, Herkowitz H, Cammisa F, Albert T, Boden SD, Hilibrand A, Goldberg H, Berven S, An H. Surgical versus nonsurgical therapy for lumbar spinal stenosis. *N Engl J Med* 2008; 358:794-810.
4. Glassman SD, Polly DW, Dimar JR, Carreon LY. The cost effectiveness of single-level instrumented posterolateral lumbar fusion at five years after surgery. *Spine (Phila Pa 1976)* 2010; 37:769-774.
5. Jansson KA, Naok-meth G, Granath F, Japy-nsson B, Blomqvist P. Health-related quality of life (EQ-5D) before and one year after surgery for lumbar spinal stenosis. *J Bone Joint Surg Br* 2009; 91:210-216.
6. Kissin I. A call to reassess the clinical value of preventive (preemptive) analgesia. *Anesth Analg* 2011; 113:977-978.
7. Deyo RA, Mirza SK, Martin BI, Kreuter W, Goodman DC, Jarvik JG. Trends, major medical complications, and charges associated with surgery for lumbar spinal stenosis in older adults. *JAMA* 2010; 303:1259-1265.
8. Kissin I. Preemptive analgesia: Problems with assessment of clinical significance. *Methods Mol Biol* 2010; 617:475-482.
9. Murphy JD, Yan D, Hanna MN, Bravos ED, Isaac GR, Eng CA, Wu CL. Comparison of the postoperative analgesic efficacy of intravenous patient-controlled analgesia with tramadol to intravenous patient-controlled analgesia with opioids. *J Opioid Manag* 2010; 6:141-147.
10. Joshi GP, Neugebauer EA. Evidence-based management of pain after haemorrhoidectomy surgery. *Br J Surg* 2010; 97:1155-1168.
11. Trabulsi EJ, Patel J, Viscusi ER, Gomella LG, Lallas CD. Preemptive multimodal pain regimen reduces opioid analgesia for patients undergoing robotic-assisted laparoscopic radical prostatectomy. *Urology* 2010; 76:1122-1124.
12. Goodwin SA. A review of preemptive analgesia. *J Perianesth Nurs* 1998; 13:109-114.
13. Moiniche S, Kehlet H, Dahl JB. A qualitative and quantitative systematic review of preemptive analgesia for postoperative pain relief: the role of timing of analgesia. *Anesthesiology* 2002; 96:725-741.
14. Duellman TJ, Gaffigan C, Milbrandt JC, Allan DG. Multi-modal, pre-emptive analgesia decreases the length of hospital stay following total joint arthroplasty. *Orthopedics* 2009; 32:167.
15. Patel GN, Rammos CK, Patel JV, Estes NC. Further reduction of hospital stay for laparoscopic colon resection by modifications of the fast-track care plan. *Am J Surg* 2010; 199:391-394; discussion 394-395.
16. Glaser J, Stanley M, Sayre H, Woody J, Found E, Spratt K. A 10-year follow-up evaluation of lumbar spine fusion with pedicle screw fixation. *Spine (Phila Pa 1976)* 2003; 28:1390-1395.
17. Pandey CK, Priye S, Singh S, Singh U, Singh RB, Singh PK. Preemptive use of gabapentin significantly decreases postoperative pain and rescue analgesic requirements in laparoscopic cholecystectomy. *Can J Anaesth* 2004; 51:358-363.
18. Radhakrishnan M, Bithal PK, Chaturvedi A. Effect of preemptive gabapentin on postoperative pain relief and morphine consumption following lumbar laminectomy and discectomy: A randomized, double-blinded, placebo-controlled study. *J Neurosurg Anesthesiol* 2005; 17:125-128.
19. Parvizi J, Porat M, Gandhi K, Viscusi ER, Rothman RH. Postoperative pain management techniques in hip and knee arthroplasty. *Instr Course Lect* 2009; 58:769-779.
20. Buvanendran A, Kroin JS. Multimodal analgesia for controlling acute postoperative pain. *Curr Opin Anaesthesiol* 2009; 22:588-593.