Comparison of continuous femoral nerve block, caudal epidural block, and intravenous patient-controlled analgesia in pain control after total hip arthroplasty: a prospective randomized study

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Abstract

Thirty-six patients who underwent primary unilateral total hip arthroplasty (THA) were randomly allocated to 4 groups with different pain control protocols; continuous femoral nerve block (FNB group), single-shot caudal epidural block with morphine (EB group), intravenous patient-controlled analgesia with fentanyl (IV-PCA group), and systemic administration of nonsteroidal anti-inflammatory drugs (NSAIDs group). Postoperative pain was assessed using the numerical rating scale (NRS) scores and the analgesic effect was compared among the groups. The NRS upon arrival at the recovery room and 6 hours after surgery in the FNB, EB, and IV-PCA groups were significantly lower than that in the NSAIDs group. The amount of additional analgesics requested by the patient was smaller in the FNB, EB, and IV-PCA groups as compared to the NSAIDs group. Regarding the complications related to the analgesia, 5 of the 9 patients in the IV-PCA group complained nausea and vomiting and received antiemetic drugs. Delay in the rehabilitation process due to drowsiness was encountered in 3 patients in this group, while no patient in the FNB and EB groups suffered from delayed rehabilitation. Considering both the analgesic effect and the potential risk of complications, continuous femoral nerve blocks and caudal epidural blocks for are recommended for postoperative pain control after THA procedure.

Introduction

Postoperative pain following total hip arthroplasty (THA) poses physical and emotional distress to the patients and may lead to a delay in functional recovery and an increase in complication rate. There have been some papers reporting how postoperative pain increases the risk of complication and affects the outcome.[1,2] Singelyn *et al.* described that pain after THA is often exacerbated by movement or reflex spasms of the quadriceps muscle, and inadequate pain control adds to reflex muscle responses with a further increase in pain.[3] Substantial and prolonged pain after THA interferes with postoperative physical therapy leading to a delay in functional recovery, which may also give rise to cardiovascular and pulmonary complications.[4-6]

Therefore, postoperative pain management in THA is of imperative importance. Conventionally, systemic administration of acetaminophen, nonsteroidal anti-inflammatory drugs (NSAIDs), and opioids were adopted as principal options. However, these medications may not be able to afford adequate pain relief and can be associated with systemic complications.[4,7,8] Although opioids are the most powerful in suppressing pain among these agents, their use can be complicated with various side effects such as respiratory depression, nausea, and vomiting.[9,10] Recently, significance of multimodal approaches including regional anesthesia, patient-controlled intravenous or epidural analgesia, and local periarticular injection has been addressed in literatures.[11-15] In 2009, Maheshwari *et al.* reviewed clinical experiences in their institute over the last 10 years and stated that perioperataive pain management has been the most substantially advanced area in the recent progress in the practice of total joint surgery.[16]

Among the techniques employed in clinical practice, lumber epidural block has been generally adopted as the measure of choice for pain management after THA.[17-19] However, as administration of anticoagulant has been popularized for thrombosis prophylaxes, a concern regarding catheter-related hematoma has been raised. Based on these recent clinical trends, peripheral nerve blocks haves gained popularity in recent years.[20-25] However, comparisons of efficacy and risk between the various pain control measures have not been well examined, and no consensus has been made to date regarding the optimization of the pain management protocol following THA.

In this study, the efficacy in pain control and occurrence of complication for continuous femoral nerve block, caudal epidural block, intravenous patient-controlled analgesia (PCA) with fentanyl, and systemic administration of NSAIDs was comparatively examined in patients who underwent THA. Based on the review of relevant articles, it was hypothesized that a peripheral nerve block can achieve better pain control with less complication, and that PCA with fentanyl is complicated with drug-related-side effects.

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Materials and Methods

Patient population

Patients scheduled for THA were included in the study. The inclusion criteria were unilateral THA, while patients with neurological or psychological problems potentially posing difficulty in pain assessment were excluded from the study population. Institutional Review Board approval was obtained and all patients signed their informed consent before participating in the study. Originally, 40 consecutive patients who met the above mentioned criteria were included in the study and randomly divided into 4 groups using the closed envelope method. During the course of the analysis of the study results, 4 patients who underwent revision THA were excluded from the study to make a comparison for subjects with more standardized characteristics. Consequently, the remaining 36 patients constituted the base of this study.

Postoperative analgesic measures included continuous femoral nerve block (FNB group), caudal epidural block (EB group), intravenous PCA with fentanyl (IV-PCA group), and oral NSAIDs (NSAIDs group). The demographics of the patients in each of the 4 groups are shown in Table 1. The patient characteristics such as age at surgery, body weight, and height were comparable among the groups with no significant intergroup difference. Preoperative diagnosis there was OA in 30 cases, and necrosis in 6 cases. All surgeries were performed under general anesthesia with the patient in the lateral position through a lateral approach by one of the authors (SN).

Pain management protocol

In the FNB group the continuous femoral nerve block was performed using 0.15% ropivacaine with a volume rate of 3 mL/h (Table 2). The blockade procedure was performed under ultrasound guidance (S-Nerve; SonoSite, Bothell, Washington, United States). The femoral artery was located below the inguinal ligament by ultrasound, and an 18-gauge short-beveled cannula (Contiplex A set; B Braun, Melsungen, Germany) was inserted just lateral to the artery. Finally, the location of the femoral nerve was determined with the aid of a peripheral nerve stimulator (Stimuplex; B Braun, Melsungen, Germany). The Seldinger technique was employed to thread a 20-gauge catheter to a depth of 10 cm into the femoral nerve sheath. In the EB group, the caudal epidural block was performed with a single dose injection of 3 mg morphine combined with 0.375% ropivacaine. A 21-gauge catheter was inserted into the caudal epidural space followed by a single dose injection of the combined agents (Table 2). In the PCA group, intravenous PCA was performed using fentanyl with a basic rate of 0.3 g/kg/h. Patients could add intravenous injections within a 20-minute lockout interval to the basic administration on their demands (Table 2).

In the NSAIDs group, pain management was performed only with NSAIDs (administration of 25-mg diclofenac sodium suppository or intravenous 50-mg flurbiprofen axetil) on patient's request. Selection of the agents was made on patient's preference (Table 2).

Evaluation

The amount of postoperative pain was evaluated in the immediate postoperative period and at 6 and 12 hours after surgery. The analgesic effect was assessed using an 11-point numerical rating scale (NRS) that ranges from 0 (no pain) to 10 (worst pain imaginable for the patient). Moreover, requirement of additional supplemental analgesics during the initial 12 hours and complications as well as functional recovery in the early postoperative period (within 14 days after surgery) were reviewed in each patient's record. The NRSs were evaluated by one of the authors (YF) who was independent of the operating surgeon. In the statistical analysis, a repeated-measures ANOVA was used to detect the difference between the groups.

Results

Clinical data about surgery were comparable for each group as shown in Table 1. No significant difference was demonstrated in the amount of intraoperative blood loss and surgical time among the groups. Additionally, there was no significant intergroup difference in the dose of fentanyl used during the surgery.

The NRS at each of the postoperative time periods in each group is shown in Table 3 and Figure 1. The NRS upon arrival at the recovery room and 6 hours after surgery in the FNB, EB, and IV-PCA groups were significantly lower than that in the NSAIDs group (P<0.05). At 12 hours, the pain score remained low only in the IV-PCA group with an average value of 1.8, while the values in other groups were higher ranging between 3.0 and 4.7. When the number of times requested for supplemental analgesic administration was compared between the groups, the average number was less than 1 in the FNB, EB, and IV-PCA groups (range, 0.3 to 0.4 times), whereas the average value in the NSAIDs group was 1.4. The number of times per patient in the FNB, EB, and IV-PCA groups were significantly lower than that in the NSAIDs group (P<0.05) (Figure 2).

Regarding the side effects and complications related to the analgesics, 5 patients in the IV-PCA group complained of nausea and vomiting and received antiemetic drugs, and 3 patients were complicated with drowsiness following surgery with a subsequent delay in the rehabilitation process. By contrast, in the FNB and EB groups, only one patient in each group experienced postoperative drowsiness, while no patients experienced a delay in rehabilitation and subsequent recovery. In the NSAIDs group, 1 patient complained of nausea and vomiting, and 2 patients in this group exhibited drowsi-

Table 1. Patient characteristics.

	FNB (n=10)	EB (n=8)	IV-PCA (n=9)	NSAIDs (n=9)
Age (years)	59.1±17.3 (28~80)	64.4±14.8 (36~80)	63.3±8.2 (48~77)	64.2±11.2 (57~86)
Female/male ratio	6/4	6/2	5/4	6/3
Weight (kg)	59.1±9.5 (42~69)	56.0±11.7 (39~75)	57.4±9.4 (47~70)	61.0±17.3 (47~82)
Height (cm)	155.9±10.4 (145~176)	157.0±14.4 (139~182)	154.5±9.1 (145~171)	156.4±8.9 (145~167)
Preop. diagnosis (OA/necrosis)	9/1	6/2	7/2	8/1
Blood loss (g)	606.3±145.7	580.3±82.8	578.7±61.9	603.8±30.0
Surgical time (min)	128.3±32.1	110.0±18.7	112.1±22.9	133.0±36.1

FNB, femoral nerve block; EB, epidural block; IV-PCA, intravenous patient-controlled analgesia; NSAIDs, nonsteroidal anti-inflammatory drugs.

Table 2. Pain management protocol.

Group	Technique	Medication
FNB	Continuous femoral nerve block	0.15% ropivacaine
EB	Caudal epidural block with morphine	3 mg morphine with 0.375% ropivacaine
IV-PCA	Intravenous patient-controlled analgesia with fentanyl	Fentanyl (0.3 μg/kg/hour)
NSAIDs	NSAIDs alone	25 mg Diclofenac sodium 50 mg Flurbiprofen axetil

FNB, femoral nerve block; EB, epidural block; IV-PCA, intravenous patient-controlled analgesia; NSAIDs, nonsteroidal anti-inflammatory drugs. Caudal epidural block in EB group was administered by a single dose injection.

Table 3. Numerical rating scale at each time period.

Group	Upon arrival at recovery room	6 hrs after surgery	12 hrs after surgery
FNB	1.7±1.3	3.2±1.2	3.4±1.6
EB	1.4±0.7	2.4±1.8	3.0±2.2
IV-PCA	1.3±0.5	1.9±1.0	1.8±1.0
NSAIDs	3.9±1.4	5.2±3.0	4.7±2.2

FNB, femoral nerve block; EB, epidural block; IV-PCA, intravenous patient-controlled analgesia; NSAIDs, nonsteroidal anti-inflammatory drugs.

ness, which- lead to a subsequent delay in rehabilitation for 2 patients (Figure 3).

Discussion and Conclusions

Recent improvements in perioperative pain management have had a major impact on the practice of total arthroplasty.[16,26] Pain control measures following THA employed in clinical practice include systemic administration of NSAIDs or opioids, intravenous PCA, epidural block, and peripheral nerve block. Among these management options, peripheral nerve block has attracted interest based on consideration of the analgesic effect as well as the risk for complication. Various modes of peripheral nerve blockade have been proposed and examined in previous literatures.[12-14] Among these techniques, the continuous femoral nerve block is one of the frequent options. However, the advantage of this technique over other methods has not been examined as critically compared to other pain control measures. In this study, the included subjects were randomly allocated into 4 groups; continuous femoral nerve block, single-shot epidural block, intravenous PCA, and systemic administration of NSAIDs. This study was designed to provide comparative information regarding the efficacy and risk of each analgesic method.

There have been some clinical studies that comparatively examined risk and benefit of various pain control methods following THA. In 1999, Singelyn *et al*. compared intravenous PCA with morphine, continuous *3-in-1* block, and epidural analgesia. These authors reported comparative pain relief achieved by these three methods, while claiming that continuous *3-in-1* block induced fewer side effects with less technical problems compared to the other two techniques. *3-in-1* blocks and femoral nerve blocks are among the same category as peripheral nerve blocks with local anesthetics. *3-in-1* blocks have an advantage of allowing a local anesthetic to spread further in the tissue plane resulting in a blockade of the femoral, lateral femoral cutaneous, and obturator nerves. However, a total anesthetic volume of 25-30 mL or more is required in this technique, which may increase the risk of local anesthetic toxicity. For a femoral nerve blockade, the amount of local anesthetic is generally 20 mL or less.[3]

In 2005, Singelyn *et al.* reported the results of their subsequent study comparing intravenous PCA with morphine, continuous femoral nerve block, and continuous epidural analgesia in THA patients. They observed comparable pain relief and postoperative recovery including the duration of hospital stay among the groups, while incidence of complication was lowest in the continuous femoral nerve

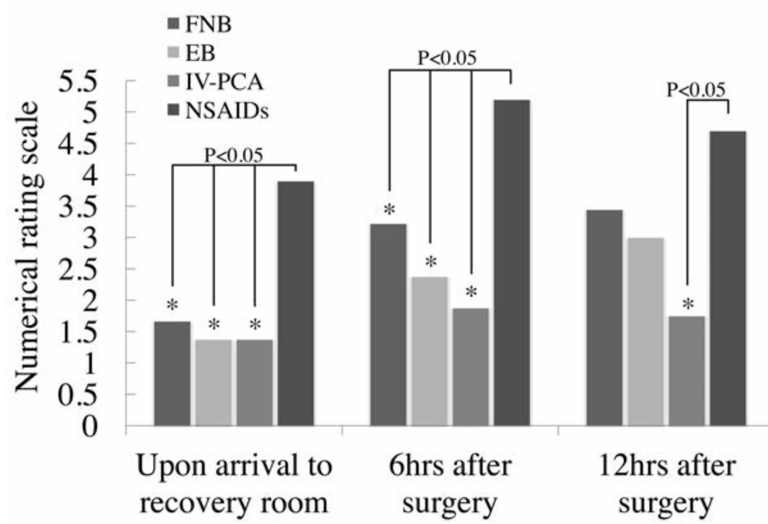

Figure 1. Numerical pain rating scale in each group at three time periods. Asterisks denote significant difference (P<0.05).

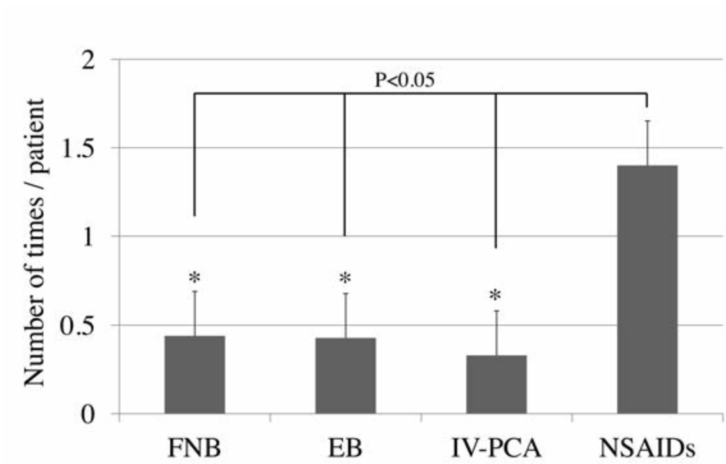

Figure 2. Requirement of supplemental NSAIDs during 12 hours after surgery (number of times /patient).

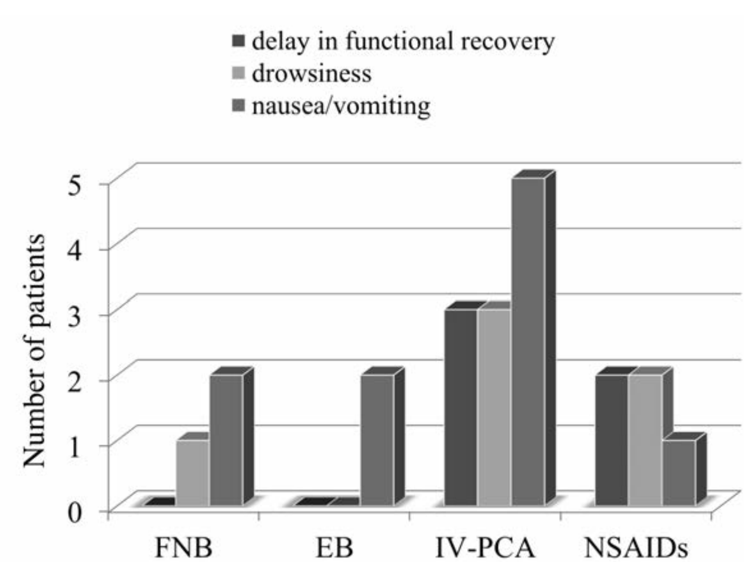

Figure 3. Postoperative complications encountered in each group.

block group.[11] Biboulet *et al*. conducted a similar study comparing continuous femoral nerve block, psoas compartment block, and intravenous PCA with morphine, and reported that the addition of a nerve or compartment block to the immediate postoperative administration of morphine could afford only a minimal supplemental effect.[27] Based on the study results, these authors posed a question on the efficacy of nerve blocks in THA patients. However, looking over the results obtained in their study, the NRS in the early postoperative period was lower in the groups with nerve blocks as compared to the score in the intravenous PCA group.

In the present study, the employed methods for pain control were continuous femoral nerve block, single-shot epidural block, intravenous PCA with morphine, and systemic NSAIDs. This combination has not been subject to a comparative analysis in previous studies. The study results showed nerve blockades and IV-PCA achieved comparative analgesic effects that were better than the systemic administration of NSAIDs. When femoral nerve and epidural blockades were compared, the analgesic effect was slightly superior and prolonged in the epidural block group though the difference was small without statistical significance. Although intravenous PCA provided a more prolonged analgesic effect after surgery, its use is not fully advocated considering the risk for the occurrence of analgesia-related complications.

There were limitations and weaknesses included in the design and contents of this study. First, the sample size (range, 8 to 10 in each group) was small with wide variation of patient characteristics. Secondly, clinical evaluation for pain was only until 12 hours after surgery and limited to the pain at rest. Thirdly, 2 kinds of analgesic agents were used in the NSAIDs group although analgesic effect of these drugs was comparable. Therefore, the obtained data are not robust enough to draw conclusive statements.

In conclusion, the analgesic effects of femoral nerve block, single-shot epidural blocks, intravenous PCA were comparable and better than that of the systemic administration of NSAIDs following THA. However, considering both the analgesic effect and the potential risk of complications, continuous femoral nerve blocks and single-shot epidural blocks are recommended for pain control after THA procedure. Although intravenous PCA with fentanyl provided a prolonged and superior pain controlling effect, the clinical advantage of this method was degraded by the potential risks for drug-related side effects and a resultant delay in functional recovery.

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