RELEVANCE OF INFILTRATION ANALGESIA IN PAIN RELIEF AFTER TOTAL KNEE ARTHROPLASTY

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ABSTRACT

Objective:The aim of the study was to assess the effect of different types of anesthesia on pain intensity in early postoperative period. Patients And Methods: A total of 87 patients (77 women, 10 men) scheduled for total knee arthroplasty (TKA) were assigned to receive either subarachnoid anesthesia alone or in combination with local soft tissue anesthesia, local soft tissue anesthesia and femoral nerve block and pre--emptive infiltration together with local soft tissue anesthesia. We assessed the pain intensity, opioid consumption, knee joint mobility, and complications of surgery. Results: Subjects with pre-emptive infiltration and local soft tissue anesthesia had lower pain intensity on the first postoperative day compared to those with soft tissue anesthesia and femoral nerve block (P=0.012, effect size 0.68). Subjects who received pre--emptive infiltration and local soft-tissue anesthesia had the greatest range of motion in the operated knee at discharge (mean 90 grades [SD 7], P=0.01 compared to those who received subarachnoid anesthesia alone, and P=0.001 compared to those with subarachnoid together with soft tissue anesthesia).
Conclusion: Despite the differences in postoperative pain and knee mobility, the results obtained throughout the postoperative period do not enable us to favour neither local nor regional infiltration anesthesia in TKA. ***Level of Evidence II, Prospective Comparative Study.***

Keywords: *Arthroplasty, replacement, knee. Anesthesia. Anesthesia, local. Nerve block. Femoral nerve.*

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INTRODUCTION

The outcome of total knee arthroplasty (TKA) is equally dependent on correctly performed "artificial joint" implantation and postoperative rehabilitation. The increasing number of such surgical procedures, as well as longer life expectancy enforces the need for early rehabilitation leading to full restoration of function in the operated joint, with the least number of early complications. To undertake exercise of the operated knee is possible only in pain free conditions. The clinical practice and review of literature show that there are different approaches to combating pain in peri- and early postoperative period.[1-7]
A lack of uniform opinion and numerous gaps in the existing studies have led us to undertake research aimed at assessing the effect of using different types of anesthesia for pain in the early postoperative period in patients after TKA.

PATIENTS AND METHODS

Patients

The study included consecutive patients with end-stage osteoarthritis who underwent primary cemented TKA. Exclusion criteria were: primary total knee arthroplasty requiring extensive soft tissue release or one that involved significant bone loss that required augmentation or stem, previous drug dependency or known allergy to any of the drugs used.
Eighty-seven patients (77 women, 10 men) were evaluated. Mean age was 68 years (range 42–88 years). Seventy-three patients received posterior-stabilized (PS) knee implants and 14 cruciate-retaining (CR) prostheses.
The subjects were divided in four groups. Group 1 consisted of 27 patients who received only subarachnoid anesthesia.

All the authors declare that there is no potential conflict of interest referring to this article.

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Patients from group 2 received subarachnoid anesthesia in combination with local anesthesia of periarticular soft tissue (20 subjects), patients from group 3 received subarachnoid anesthesia in combination with local periarticular soft tissue anesthesia and postoperative femoral nerve block (20 subjects), and patients from group 4 received subarachnoid anesthesia in combination with pre-emptive infiltration anesthesia and local periarticular soft tissue anesthesia (20 subjects). The characteristics of the patients are shown in Table 1.

The study was approved by the Bioethical Board (number RNN/133/08/KB) and informed written consent was obtained from all the patients.

Table 1. Subjects' characteristics.

Characteristic	Groups of patients			
	1	2	3	4
N (number of men)	27 (2)	20 (1)	20 (3)	20 (4)
Age, mean (SD) years	69.2 (6)	67.1 (9.4)	65.9 (11)	69.3 (9.5)
Body mass index, mean (SD) kg/m^2	29.5 (4.1)	30.6 (4.5)	29.1 (4)	30.2 (4.1)
Symptoms since, mean (SD) years	8.4 (6.6)	10.6 (5.2)	9.8 (5.4)	8.1 (4.1)
Range of movement, mean (SD) grades				
Before surgery	108 (21)	108 (12)	110 (9)	112 (9)
After surgery	84 (9)	84 (7)	87 (9)	90 (7) [a b]
Prosthesis				
PS	19	18	18	18
CR	8	2	2	2
Knee axis				
Varus mean (SD) degrees	7.76 (6.87)	8.43 (5.81)	8.08 (6.20)	11.00 (6.60)
Valgus mean (SD) degrees	6.20 (8.94)	10.38 (9.62)	9.70 (7.87)	11.67 (9.83)

PS: posterior stabilized; CR: cruciate retaining.
Group 1: only subarachnoid anaesthesia; group 2: subarachnoid anesthesia and local anesthesia of periarticular soft tissue; group 3: subarachnoid anesthesia and local periarticular soft tissue anesthesia and postoperative femoral nerve block; group 4: subarachnoid anesthesia and pre-emptive infiltration anesthesia and local periarticular soft tissue anaesthesia. [a]: P=0.01 as compared to group 1. [b]: P=0.001 as compared to group 2.

Surgery and rehabilitation

The surgery was carried out in bloodless field using a pneumatic tourniquet. Pre-emptive infiltration anesthetized the skin and subcutaneous tissue at the line of incision with 20 ml of 1% lidocaine. Arthrotomy was performed with the medial parapatellar approach. The prostheses were stabilized with bone cement, securing the tibial shaft platforms by the press-fit technique. Intraoperatively, the posterior joint capsule, Hoffa's body, patellar tendon and quadriceps tendon were injected with 20 ml of 0.25% solution of 0.05 g bupivacaine with 0.05 mg adrenaline. No drainage was used. Tourniquet was released after applying a sterile dressing and soft-padded bandage.

Femoral nerve block was performed by administering 20-25 ml of 0.5% bupivacaine. For deep vein thrombosis prophylaxis, all the patients had either subcutaneous nadroparin (Fraxiparine, GlaxoSmithKline, UK) 40 mg daily or oral rivaroxaban (Xarelto, Bayer Schering Pharma, Germany) 10 mg daily and mechanotherapy with compression stockings from the second day after the surgery. Perioperative antibiotic prophylaxis was given as a single dose of an antibiotic administered intravenously half an hour before the operation. Rehabilitation was initiated on the first postoperative day and the rehabilitation protocol in all four groups was identical. On the first day after surgery, the patients were verticalized and active flexion of the operated knee to the angle of 90° with exercises on continuous passive motion splint were introduced. Patients were able to ambulate with mobility aids one day after the surgery with weight bearing on the operated limb "to the limit of pain".

Assessment of the main outcome factor

The intensity of pain was chosen as the main outcome factor. It was assessed at rest using the Visual Analogue Scale (VAS) with possible score range 0 to 10, with 10 representing the most severe pain. The intensity of pain was evaluated on day 1, 2, 3, 7 and 10 after the surgery (VAS1–VAS10). For the assessment of pain medication requirement, the medicaments administered were divided according to the WHO analgesic ladder. The mobility of the operated knee was assessed with a goniometer.

Clinical examination

The subjects in all groups underwent clinical evaluation encompassing severity of pain, the need for analgesics, and the range of motion activity in the operated knee during the postoperative period. The examining surgeon was blinded to which group the patient belonged.

Statistical analysis

Quantitative variables were described as mean, standard deviation, median, skewness and kurtosis. To assess data normality the Shapiro-Wilk test was performed. The two-way analysis of variance (ANOVA) for repeated measures was used to compare the differences between the groups. Continuous data were analyzed using Student's t-test for parametric or Mann-Whitney test for non-parametric data as appropriate. Binary data in 2 x 2 tables were evaluated by Fisher's exact test. The effect size was assessed with Cohen's d index. No prior sample size determination was made due to the observational character of the present study. However, a post hoc power calculation for unequal variances was performed. Statistical power for the assessment of the main outcome factor was calculated to be approximately 81% to detect a 10% difference between groups at alpha of 0.05. Analyses were performed with SPSS for Windows 15.0.0 (SPSS, Chicago, IL, USA) and we considered a two-tailed P less than 0.05 as statistically significant.

RESULTS

As the number of males and females differed in each group, possible differentiation of VAS results and the extent of physical activity dependent on gender were primarily analyzed. We found that gender did not affect the range of motion or the VAS results. The ratio of PS to CR implants did not differ significantly between the study groups. Preliminary assessment of the impact of the prostheses type (PS, CR) on the VAS value showed that VAS1 was lower among patients who received CR prosthesis (mean 4.0 [SD 1.3] *vs*. 5.4 [2.0] for PS prosthesis, P=0.007). For VAS2-VAS10, the pain perception did not depend on the type of prosthesis.

Evaluation of pain

The lowest pain intensity on the first postoperative day was observed in group 4, and the highest in group 3 (P=0.012), with a large effect size equalling 0.68. The differences in pain intensity from day 2 after the surgery were not statistically significant (Figure 1). A comparison of patients from group 1 and 2 revealed that in the range VAS2-VAS10, the effect of periarticular soft tissue anesthesia was lower than average. The effect size was moderate, ranging 0.31–0.43.

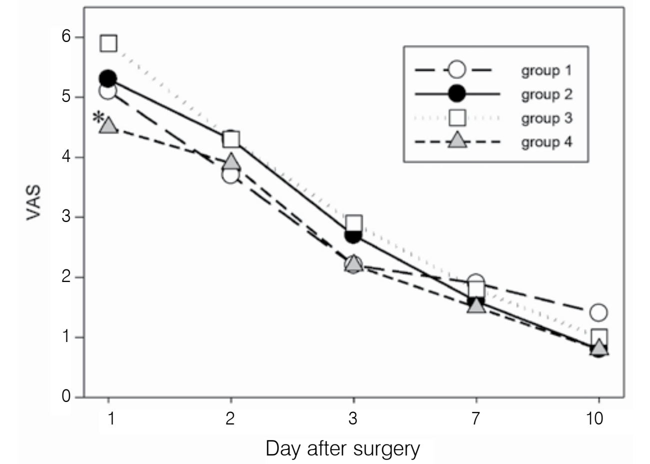

Figure 1. Mean pain intensity measured with Visual Analog Scale (VAS) 1, 2, 3, 7 and 10 days after surgery in patients undergoing spinal anaesthesia alone (group 1, n=27) or combined with local anaesthesia of periarticular soft tissue (group 2, n=20), periarticular soft tissue anesthesia and postoperative femoral nerve block (group 3, n=20) and pre-emptive infiltration anaesthesia and local periarticular soft tissue anaesthesia. Possible score range 0 to 10, with 10 representing the biggest pain. *$P<0.05$ compared to group 3.

The requirement of analgesia

An assessment of the demand for pain medication by the WHO analgesic ladder showed that that 80% of patients in group 1 and 3, and 60% in group 2 and 4 did not require strong analgesics. However, this difference was not statistically significant. Medicines from the first and second level of the analgesic ladder were given to patients in group 3 for the longest time. The time of WHO analgesic ladder drugs need was similar in all groups (P=0.591). No statistically significant difference was found in the average amount of medication used from subsequent analgesic ladder levels in each group of anesthesia. The average quantities of all drugs used in groups 1–4 were similar.

Mobility in the operated joint

The greatest range of motion on the day of discharge was observed in patients from group 4. These subjects had a significantly larger flexion range at discharge than patients from group 1 and group 2 (Table 1). Varying degrees of extension loss in the operated knee were observed in groups 1–3, but differences between groups were not statistically significant (Table 1). Only patients from group 4 achieved full extension in the operated joint on discharge. We found that neither gender nor prosthesis type affected the range of motion or pain intensity.

Complications

The assessment included local complications concerning such perioperative events as bleeding, hematoma, nerve palsy, vascular injury, limb ischemia, abnormal wound healing. In group 1, there were no local complications. We observed prolonged healing of the surgical wound in two patients in group 2, and in one in group 3. The results of bacteriological and mycological tests were negative. Superficial infection with prolonged wound healing was observed in one patient in group 4 (methicillin--susceptible *Staphylococcus epidermidis*, MSSE, was isolated from the wound), and prolonged surgical wound healing in 3 patients, in whom the results of bacteriological and mycological tests were negative. The differences in the number of complications were not statistically significant.

DISCUSSION

Our study shows that subjects undergoing spinal anesthesia together with pre-emptive infiltration and local soft tissue anesthesia experience less pain than those who have spinal anesthesia in combination with periarticular soft tissue anesthesia and postoperative femoral nerve block on the first postoperative day. We did not find any differences in pain intensity between these groups on the following days.

To the best of our knowledge, our study is the first attempt to analyze the influence and report the advantage of pre-emptive analgesia and local periarticular soft tissue infiltration for pain relief following TKA. Up to date, most studies have neither demonstrated benefits, nor adverse effects of pre-emptive infiltration.[8,9] However, almost all of these studies used unimodal analgesic regimens. In the authors' opinion, the use of a multimodal model of pre-emptive anesthesia will help explain the divergence between the effectiveness of pre-emptive analgesia in animal models, and absence thereof in most studies in humans.[10] There is also evidence suggesting that the efficacy of pre-emptive infiltration anesthesia depends on the type of operation conducted. Aida et al. proved that pre-emptive analgesia is effective in limb surgery and mastectomy, but ineffective for gastrectomy, hysterectomy, herniorrhaphy, and appendectomy.[11] Møiniche *et al.*,[12] while analyzing sixteen cases of pre-emptive infiltration and similar treatments of the surgical wound, did not observe any pain reduction in patients with pre-emptive analgesia. Their assessment included herniorrhaphy, appendectomy, tonsillectomy, TKA, laparoscopy and odontological surgery procedures.

We observed no differences in quantities of drugs from successive levels of the analgesic ladder administered to patients from all groups assessed. Noteworthy, medicines from the first and second level of the analgesic ladder were for the longest time administered to patients with postoperative femoral nerve block.

Analgesia protocol after TKA is a well-known clinical problem. Various techniques are applied to reduce postoperative pain in these patients. Fu *et al*.[13] compared the analgesic effectiveness of intraarticular administration of morphine, bupivacaine and betamethasone, noting a reduction in demand for morphine, lower VAS at 0-36 hours after surgery, and active flexion of 90 degrees on day 15 after TKA in this group of patients. Andersen *et al*.,[14] while evaluating the analgesic efficacy of local intra- or extraarticular administration of medicines during knee surgery, observed a tendency to improve analgesic effect when additional extraarticular anesthesia was administered, although the observations did not give preferentiality to any specific periarticular area. Local anesthetics reversibly block nerve conduction near the site of administration, thus causing a temporary loss of sensation in a limited area. Vendittoli *et al*. in a randomized study in subjects receiving patient-controlled morphine administration reported benefits of local infiltration anesthesia versus self-monitoring of morphine doses. The subjects from the former group had less nausea incidents due to decreased morphine intake.[15] Ong *et al*. conducted an analysis of randomized controlled trials (RCTs) focused on the assessment of preoperative analgesia with a similar course of pain management regimen in the postoperative period. While the pre-emptive epidural anesthesia resulted in permanent improvement in all three outcome variables, the pre-emptive infiltration anesthesia and administration of non--steroidal anti-inflammatory drugs (NSAIDs) improved analgesic intake and the time to first analgesic intervention, though it did not affect the level of pain perception.[9]

Inadequate pain control after TKA can prolong hospitalization and, consequently, contribute to the increase in the number of complications, such as limiting the range of movement in the operated joint, thromboembolic complications, pneumonia or coronary disorders.[16,17] With regard to the surgical technique, a prospective randomized study demonstrates that the length of incision has no effect on postoperative pain.[18]

We have found that patients who were administered pre-emptive infiltration together with soft tissue anesthesia obtained a better range of motion in the operated knee 10 days after the surgery. All subjects from this group obtained full extension of the operated joint, and the flexion on discharge averaged 90 degrees. Another study confirmed the effect of periarticular anesthesia. Maheshwari et al. reported that intraoperative infiltration of ligaments, tendons and other parts of the knee joint with a combination of bupivacaine, methylprednisolone, morphine, epinephrine and cefuroxime enabled significant improvement, not requiring additional redression or extended rehabilitation.[6]

Other authors advocated pre- and intraoperative use of femoral nerve block.[19, 20] Proponents argue that femoral nerve block reduces the requirement for intraoperative analgesia, shortens hospital stay, and can lead to earlier mobilization of the patient. Sharma et al. draw attention to the delay of early mobilization due to inflammation of the femoral nerve or cardiac dysrhythmia.[21] In our observation, within 10 days after surgery, the patients with postoperative femoral nerve anesthesia obtained a range of motion of the operated knee similar to that of the subjects who underwent other types of anaesthetic treatment. We observed that the level of pain intensity in these patients was relatively high on the first day after the surgery and that they received drugs from the first and second level of the analgesic ladder for the longest time. We found that patients undergoing TKA with CR implants had less pain than those who received PS prostheses on the first post-operative day. More severe pain in subjects with PS implants may be due to posterior cruciate ligament excision and preparation of femur notch. Such differences in pain intensity between patients with different implant designs have not yet been reported. The strengths of our study include a prospective evaluation as well as standardization of hospitalization procedures performed by the same operating team and the use of identical rehabilitation and pharmacotherapy regimen, a subjective measurement of pain with VAS, and an objective evaluation by an indirect method assessing the range of motion in the operated joint. We also took into account possible impact of such factors as gender and prosthesis type on the perception of pain. However, the study has some limitations. The number of subjects does not entitle us to express an opinion about the strength of the results obtained. It is, nevertheless, sufficient for statistical evaluation.

CONCLUSIONS

In conclusion, postoperative pain after TKA can be significantly decreased on the first postoperative day, if the surgery is performed in subarachnoid anesthesia together with pre-emptive infiltration and intraoperative periarticular soft tissue anesthesia. Pre-emptive infiltration together with soft tissue anesthesia allows improving the range of motion in the operated knee compared to subarachnoid anesthesia alone and in combination with periarticular soft tissues anesthesia

Both regional and local infiltration analgesia has gained widespread recognition in modern medicine. However, the results obtained throughout the TKA postoperative period do not enable us to favour either of them. It seems that the most important element of effective analgesic therapy may be elimination of analgesic gaps which induce sinusoidal pain cycle.

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