



## Analgesic efficacy and safety of four different anesthesia/postoperative analgesia protocols in patients following total hip arthroplasty

Analgetska efikasnost i bezbednost četiri različita protokola anestezije/postoperativne analgezije kod pacijenata nakon aloartoplastike kuka

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### Abstract

**Background/Aim.** Hip replacement surgery can initiate significant postoperative pain caused by bone alterations, implant, and soft tissue or nerve injuries. Postoperative analgesia using regional techniques has been shown to have numerous advantages over the intravenous use of morphine. However, numerous side effects and complications of postoperative continuous epidural analgesia have been reported recently. The aim of this prospective, randomized study was to investigate whether continuous lumbar plexus block can be a safe and efficacious alternative for postoperative analgesia in comparison with epidural analgesia and patient-controlled analgesia with morphine (PCA morphine) for hip arthroplasty. **Methods.** This prospective study included 60 patients, scheduled for total hip arthroplasty. Patients were randomized into 4 groups: the group central nerve block – epidural (CNB), the group peripheral nerve block – lumbar plexus block (PNB), the group spinal anesthesia-PCA morphine (SAM) and the group general anesthesia-PCA morphine (GAM). The quality of analgesia and side effects (hypotension, nausea, vomiting, urinary retention) were recorded in all groups at 4 h, 12 h, and 24 h after surgery. Pain scores were assessed using Visual Analogue Scale (VAS), both at rest and on moving. **Results.** Our findings demonstrated

that the use of a continuous lumbar plexus block provides effective analgesia at rest and on moving, during 24 h after hip arthroplasty. Pain scores varied significantly among the groups 4 h postoperatively ( $F = 21.827; p < 0.01$ ), 12 h postoperatively ( $F = 41.925; p < 0.01$ ) and 24 h postoperatively ( $F = 33.768; p < 0.01$ ) with the highest scores  $\geq 3$  in the GAM group. Patients from the PNB group had satisfactory analgesia, comparable with patients from the CNB group. The incidence of nausea was significantly lower in the PNB group 12 h after the operation ( $\chi^2 = 9.712; p < 0.01$ ). The incidence of urine retention was significantly different 12 h after the operation, with a presence only in the CNB group, with the incidence of 33.3% ( $\chi^2 = 16.365; p < 0.01$ ). In all studied groups, the incidence of hypotension was not significantly different postoperatively. **Conclusion.** Administration of postoperative analgesia using continuous lumbar plexus block produces satisfactory analgesia with a low incidence of side effects when compared to epidural analgesia or parenteral opioids following hip arthroplasty.

**Key words:** arthroplasty, replacement, hip; pain, postoperative; nerve block; lumbosacral plexus; analgesia; methods; analgesia, epidural; pain measurement.

### Apstrakt

**Uvod/ Cilj.** Zamena totalne proteze kuka može prouzrokovati značajne bolove nakon operacije, kako zbog hirurške traume kosti i prisustva implanta, tako i zbog oštećenja mekih tkiva i živaca. Metode postoperativne analgezije koje uključuju neku od tehnika regionalne anestezije imaju mnogobrojne prednosti u odnosu na intravensku primenu morfina postoperativno.

Međutim, u skorije vreme su objavljeni mnogobrojni neželjeni efekti i komplikacije kontinuirane epiduralne analgezije. Cilj ove prospektivne, randomizovane studije bio je da se utvrdi da li kontinuirani blok lumbalnog pleksusa predstavlja sigurnu i efikasnu alternativu za postoperativnu analgeziju u poređenju sa epiduralnom analgezijom i pacijent kontrolisanom analgezijom (PKA) morfinom kod aloartoplastike kuka. **Metode.** U ovu prospektivnu studiju bilo je uključeno 60 pacijenata, pred-

viđenih za aloartroplastiku kuka. Pacijenti su bili raspoređeni u četiri grupe: grupa centralni neuroblok – epidural (CNB), grupa periferni neuroblok – blok lumbalnog pleksusa (PNB), grupa spinalna anestezija – PKA morfin (SAM), i opšta anestezija – PKA morfin (OAM). Kvalitet analgezije i učestalost neželjenih efekata (hipotenzije, muke, povraćanja, retencije urina) praćeni su u svim grupama 4 h, 12 h i 24 h nakon operacije. Jačina bola procenjena je pomoću vizuelne analogne skale (VAS), tokom mirovanja i pri pokretima. **Rezultati.** Ovo istraživanje pokazalo je da se primenom kontinuiranog bloka lumbalnog pleksusa obezbeđuje efikasna analgezija u mirovanju i pri pokretima tokom 24 h nakon aloartroplastike kuka. Jačina postoperativnog bola varirala je značajno među grupama 4 h nakon operacije ( $F = 21,827$ ;  $p < 0,01$ ), 12 h nakon operacije ( $F = 41,925$ ;  $p < 0,01$ ) kao i nakon 24 h ( $F = 33,768$ ;  $p < 0,01$ ), sa najvećim zabeleženim skorom  $\geq 3$  u grupi OAM. Pacijenti iz grupe PNB

imali su zadovoljavajuću analgeziju, sličnu pacijentima iz CNB grupe. Incidencija muke bila je značajno niža u PNB grupi 12 h nakon operacije ( $\chi^2 = 9,712$ ;  $p < 0,01$ ). Incidencija retencije urina značajno se razlikovala 12 h nakon operacije i pojavljivala se jedino u grupi CNB, sa učestalošću od 33,3% ( $\chi^2 = 16,365$ ;  $p < 0,01$ ). Nije bilo statistički značajnih razlika u učestalosti hipotenzije u ispitivanim grupama. **Zaključak.** Postoperativna analgezija nakon aloartroplastike kuka kontinuiranom blokadom lumbalnog pleksusa obezbeđuje zadovoljavajuću analgeziju sa malim brojem neželjenih efekata, u poređenju sa epiduralnom analgezijom i parenteralnom primenom opioida.

#### Ključne reči:

**artroplastika kuka; bol, postoperativni; blokada živca; lumbosakralni predeo; analgezija; metode; analgezija, epiduralna; bol, merenje.**

## Introduction

Hip replacement surgery can cause significant postoperative pain and surgical stress response. The ideal method of pain relief management for this type of surgery has not been established yet<sup>1</sup>. Inadequate pain relief leads to a higher risk of respiratory and cardiovascular complications, such as pneumonia caused by hypoventilation, tachycardia, hypertension, myocardial ischemia and myocardial infarction. Untreated acute pain has been found to be one of the risk factors for poor wound healing and transition into the chronic pain. Furthermore, early postoperative mobilization of the patient and hospital discharge can be delayed in these patients. More severe pain often requires opioid therapy. Increased opioid use may result in a subsequent increase in nausea and vomiting by stimulation of the chemoreceptor trigger zone in the floor of the fourth ventricle<sup>2</sup>.

Pain related to the hip surgery itself can be associated with an implant, bone alterations and soft tissue or nerve injuries. Apart from surgical injury, patient's functional status, age, comorbidity, body mass index (BMI) and anxiety may influence the postoperative pain scores.

The hip joint is innervated by three nerves: femoral nerve (L2, L3, L4), sciatic nerve (L4, L5, S1, S2, S3) and obturator nerve directly from its anterior division (L2, L3, L4). Cutaneous innervation of the lateral aspect of the thigh is predominantly supplied by the lateral cutaneous nerve of the thigh. It is a sensory branch of the lumbar plexus, arising from the posterior divisions of the anterior rami of L2 and L3 spinal nerves sometimes with variable innervation proximally from the sub-costal nerve (T12)<sup>3</sup>.

The origin of postoperative pain has been linked to nociceptive stimuli, by releasing of primary mediators such as prostaglandins, leukotrienes, bradykinins, and 5-hydroxytryptamine. Consequently, the release of secondary mediators – peptides [calcitonin gene-related protein (CGRP), substance P and cholecystokinin] at the site of injury stimulate nociceptors. Impulses from the peripheral nociceptors travel *via* A delta and C fibers to synapse in the spinal cord<sup>4</sup>. Greater understanding of pain mechanisms has led recently to the concept of preemptive analgesia. Analgesics

have been given before hip surgery starts. Central sensitization and worsening of postoperative pain have been prevented by administration of analgesics prior to painful stimuli<sup>5</sup>.

For this type of hip surgery, both general and regional anesthesia can be performed successfully. Regional anesthesia has been shown to have numerous advantages over general anesthesia for hip replacement. Reduction in intraoperative blood loss due to lowering mean arterial pressure and venodilatation and diminution of risk for deep vein thrombosis by almost 50% have been the main benefits associated with regional anesthetic techniques. Initiation of postoperative analgesia can be achieved using catheter techniques<sup>6</sup>.

### *Epidural analgesia*

Epidural analgesia provides superior analgesia even using low dose continuous infusions. The combination of an opioid and a local anesthetic has been advocated due to synergistic analgesic effect. Therefore, the concentration of each component in the solution can be reduced<sup>7</sup>. On the other hand, numerous side effects and complications of this method have been reported recently. Epidural analgesia has been associated with technical failures, hypotension, urinary retention, a bilateral motor block which may postpone ambulation and unrecognized compartment syndromes. Especially in the population of orthopedic patients, spinal hematomas are found to be more frequent due to higher doses of thromboprophylactic agents and platelet antiaggregation therapy<sup>8</sup>.

### *Intravenous morphine*

Postoperative analgesia using morphine hydrochloride *via* patient controlled analgesia (PCA) pumps presents the most sophisticated method for delivering intravenous (*iv*) opioids. Narrow therapeutic index of these drugs can be overcome using PCA pumps. On the contrary, most of patients scheduled for hip replacement are elderly people and their education for this method of analgesic administration may be difficult and time-consuming. *Iv* morphine can have numerous side effects - nausea, vomiting and sedation of the patient, which can delay rehabilitation<sup>9</sup>.

### Peripheral nerve blocks (lumbar plexus block)

Peripheral nerve blocks (PNBs) have become an increasingly popular alternative to epidural analgesia for postoperative pain relief after hip replacement. Insufficient evidence supports the efficacy of PNBs, suggesting that analgesia can be comparable to epidural analgesia, with a minimal motor block that enables early mobilization. Usage of PNBs has been associated with fewer side effects, such as hypotension, urinary retention. Morphine side effects – sedation, nausea, and vomiting, appear less frequently<sup>10</sup>. Innervation of the hip joint is complex, including all three main nerves which originate from the lumbar plexus – femoral (L2, L3, L4), obturator (L2, L3, L4) and cutaneous lateral femoral nerve of the thigh (L2/L3). Therefore, only lumbar plexus block can provide satisfactory blockade and efficacious postoperative analgesia<sup>11</sup>. Lumbar plexus block is considered to be an advanced method for the peripheral blockade. Lumbar plexus is formed from spinal roots which arise from L1-L4 intervertebral foramina with contribution of T12. Their anterior branches compose the lumbar plexus within the psoas muscle, and after division, emerge from the muscle into pelvis as individual nerves.

The aim of the study was to investigate whether continuous lumbar plexus block can be a safe and efficacious alternative for postoperative analgesia in comparison with epidural analgesia and PCA morphine for total hip replacement. Therefore, quality of postoperative analgesia, using visual analogue scale (VAS) and a number of side effects (nausea, urinary retention, and episodes of hypotension) were recorded in four groups of patients (lumbar plexus analgesia, epidural analgesia, and PCA morphine following general and spinal anesthesia).

### Methods

After obtaining ethical committee approval, 60 patients, aged  $59.61 \pm 9.92$  years, American Society of Anesthesiologist [(ASA) physical status II-III], scheduled for unilateral total hip arthroplasty were included in this prospective, randomized study. Type of implant prosthesis was influenced by the age of the patient (cementless prostheses – 73.3%, cemented prostheses – 18.3% and hybrid prostheses – 8.3%).

Among the groups, there were no significant differences, regarding the age, gender, BMI, type of implant prosthesis, duration of surgery and postoperative blood loss in 24 h. The values are shown in Table 1.

Before inclusion, written informed consent was obtained from each patient. Exclusion criteria were: known allergy to local anesthetics and opioids, chronic pain, chronic opioid medication, contraindications to central or peripheral nerve block (local skin infections, coagulation disorders). Patients were randomized into 4 groups of 15 patients: the group central nerve block – epidural (CNB), the group peripheral nerve block – lumbar plexus block (PNB), the group spinal anesthesia + *iv* morphine (SAM) and the group general anesthesia + *iv* morphine (GAM).

All patients received midazolam 0.03 mg/kg *iv*, 20 min before planned surgery. Preoperatively, in the group CNB, epidural space was identified with normal saline, using 18 G epidural needle. Thereafter, epidural catheter 20 G (Braun, Meslungen, Germany) was inserted. A bolus of 3 mL levobupivacaine 0.5% and fentanyl 50 µg was administered *via* epidural catheter before anesthesia induction. Intraoperatively, boluses of 5 mL levobupivacaine 0.5% were added on a regular basis, every 30 min. Anesthetic induction was performed using propofol 2 mg/kg, fentanyl 100 µg and rocuronium 0.6 mg/kg. Following endotracheal intubation, anesthesia was maintained using sevoflurane 1–2% in a 50%/50% mixture of oxygen and N<sub>2</sub>O. Postoperative analgesia was maintained *via* epidural catheter during the first 24 h, by continuous infusion of a mixture – levobupivacaine 0.1% and fentanyl 2 µg/mL, 8–15 mL/h.

In the group PNB, lumbar plexus was identified by nerve stimulator according to Capdevila's approach<sup>12</sup>, using 15 cm long needle for the peripheral block. Contractions of the quadriceps muscle ("dancing patella sign") were obtained using an initial current of 1–2 mA. After twitches were observed, the current was reduced to 0.5 mA. A peripheral catheter (Braun, Meslungen, Germany) was inserted into psoas compartment where lumbar plexus is situated. A total of 20 mL levobupivacaine 0.25% was administered. Following catheter insertion, general anesthesia was performed in the same way as in the group CNB. Postoperative analgesia was maintained *via* the peripheral catheter during the first 24 h, by continuous infusion of levobupivacaine 0.25%, 5–10

Table 1

Patient baseline and surgical characteristics in the first 24 h after total hip arthroplasty

Variable	CNB	PNB	SAM	GAM	Significance
Age (years), $\bar{x} \pm SD$	59.60 ± 11.14	59.40 ± 8.87	58.00 ± 11.81	61.46 ± 8.13	F = 0.298 (ns)
Gender (M/F), n	8/7	7/8	8/7	7/8	p > 0.05
BMI (kg/m <sup>2</sup> ), $\bar{x}$	27.57	28.03	28.29	27.86	p > 0.05
Type of implant prosthesis (U/C/H), n	11/3/1	12/2/1	11/3/1	10/3/2	$\chi^2 = 0.349$ (ns)
Duration of surgery (min), $\bar{x} \pm SD$	91 ± 38	99 ± 52	88 ± 43	93 ± 47	p > 0.05
Postoperative blood loss in 24 h (mL), $\bar{x} \pm SD$	926.66 ± 295.11	800.00 ± 280.30	810.66 ± 237.50	756.66 ± 274.42	F = 1.064 (ns)

M – male/F – female; BMI – body mass index; U – uncemented/C – cemented/H – hybrid; ns – non significant; CNB – central nerve block (epidural); PNB – peripheral nerve block (lumbar plexus block); SAM – spinal anesthesia + intravenous (*iv*) morphine; GAM – general anesthesia + *iv* morphine;  $\bar{x}$  – arithmetic mean; SD – standard deviation; n – number of patients.

mL/h. Initial titration was performed postoperatively, using a 10 cm VAS and providing pain score lower than 3 cm.

In the group GAM, all patients received general anesthesia, using the same protocol as it was used for the patients from the CNB and the PNB group. The average duration of general anesthesia was  $135 \pm 52$  min and did not differ significantly among the groups CNB, PNB and GAM. Preoperatively, patients included into the SAM and the GAM group were informed about postoperative pain management using PCA devices. In the recovery room, patients from the SAM and the GAM group received initial *iv* boluses of morphine hydrochloride (5 mg doses at 5 min intervals), titrated manually until their pain score was lower than 3 on a 10 cm VAS. Thereafter, PCA analgesia was initiated. PCA pump ( $\mu$ SP 6000, Arcomed ag, Switzerland) was connected, delivering 1 mg doses of morphine *iv*, with a 7 min lockout period and a maximum dose of 20 mg over 4 h.

After the surgery, the patients from all groups were transferred to the post-anesthesia care unit (PACU) and after a 2 h observation period, to the orthopedic ward.

In the SAM group, all the patients received spinal anesthesia in sitting position, using 25 G, 88 mm Quincke tip needles (Braun, Meslungen, Germany). A total of 12.5–17.5 mg of hyperbaric bupivacaine 0.5% was administered into subarachnoid space at the L3-4 spinous level. Postoperatively, morphine was administered *iv*, using PCA pump.

#### Statistics

The methods of descriptive statistics were applied. The numerical variables were presented as mean value, minimum, maximum, standard deviation, while the categorical ones as proportions (percentages). Dependence of the parameters in order to check the differences was analyzed using Pearson's  $\chi^2$  test and Fisher's exact test. The differences were considered to be significant when  $p < 0.05$ .

The quality of analgesia and side effects (hypotension, nausea, vomiting, urinary retention) were recorded in all groups at 4 h, 12 h, and 24 h after surgery. Pain scores were

assessed using VAS at rest (VAS1) and on moving (VAS2). Patients were asked to report on episodes of nausea and/or vomiting at 4 h, 12 h, and 24 h after surgery. The non-invasive arterial pressure was measured hourly, on regular basis and recorded at 4 h, 12 h, and 24 h after surgery. Values lower than 100/70 mmHg, were considered as hypotension. Inability to urinate spontaneously with a presence of bladder distention and the need for urinary catheterization was recorded at 4 h, 12 h, and 24 h after the surgery.

## Results

### Quality of analgesia

Data analysis showed that postoperative pain scores at rest and on moving were significantly different among the groups (Table 2). Four hours after the operation, the lowest average level of pain was recorded in the CNB group, both at rest ( $0.07 \pm 0.25$ ) and on moving ( $0.4 \pm 0.73$ ). In the PNB and the SAM group, the level of pain was moderate with the highest score at rest 3 vs 4, and on moving up to 6. In the GAM group, pain at rest varied significantly, with a wide range at VAS from 1–9 ( $F = 21.827$ ;  $p < 0.01$ ).

Twelve hours after the operation, average scores in VAS1 and VAS 2 were significantly different ( $F = 41.925$ ;  $p < 0.01$ ). The GAM group had significantly higher pain scores, both at rest and on moving, when compared to other groups. The lowest pain scores at VAS were recorded in the CNB group, with no patient suffered from any pain at rest (Table 2).

Finally, 24 h after the operation, the average level of pain in all groups was reduced. Pain scores varied still significantly among the groups ( $F = 33.768$ ;  $p < 0.01$ ). The highest scores were recorded in the GAM group, both at rest and on moving. On the contrary, the lowest average pain scores were noticed in the CNB group.

While reduction of pain during 24 h was similar in the PNB and the GAM group, with the highest scores 4 h after the operation, the SAM group showed the highest levels of pain scores 12 h after the operation.

**Table 2**  
**Pain scores on visual analogue scale (VAS) at rest (VAS1) and on moving (VAS2) in the CNB, the PNB, the SAM and the GAM group 4 h, 12 h and 24 h after total hip arthroplasty**

VAS	Time after operation (h)			Average VAS score
	4	12	24	
VAS1				
CNB	$0.07 \pm 0.25$ (0/1)	$0.00 \pm 0.00$ (0/0)	$0.00 \pm 0.00$ (0/0)	$0.02 \pm 0.09$ (0/1)
PNB	$1.47 \pm 1.24$ (0/4)	$0.93 \pm 0.96$ (0/3)	$0.47 \pm 0.51$ (0/1)	$0.95 \pm 0.87$ (0/4)
SAM	$1.27 \pm 0.88$ (0/3)	$2.47 \pm 0.99$ (1/4)	$1.67 \pm 0.72$ (0/3)	$1.80 \pm 0.85$ (0/4)
GAM	$3.93 \pm 2.12$ (1/9)	$2.73 \pm 1.22$ (1/6)	$2.73 \pm 1.22$ (1/3)	$3.13 \pm 1.48$ (1/9)
VAS2				
CNB	$0.40 \pm 0.73$ (0/2)	$0.13 \pm 0.35$ (0/1)	$0.27 \pm 0.45$ (0/1)	$0.27 \pm 0.59$ (0/2)
PNB	$3.20 \pm 1.97$ (0/6)	$2.80 \pm 1.61$ (1/6)	$1.53 \pm 1.06$ (0/4)	$2.56 \pm 1.47$ (0/6)
SAM	$3.07 \pm 1.54$ (1/6)	$5.07 \pm 1.14$ (4/7)	$3.57 \pm 0.93$ (2/5)	$3.90 \pm 1.21$ (1/7)
GAM	$6.80 \pm 1.93$ (2/9)	$5.47 \pm 1.88$ (2/8)	$4.86 \pm 1.84$ (2/8)	$5.71 \pm 1.89$ (2/9)

Results are given as arithmetic mean  $\pm$  standard deviation (minimal/maximal score);

CNB – central nerve block (epidural); PNB – peripheral nerve block (lumbar plexus block);

SAM – spinal anesthesia + intravenous (*iv*) morphine; GAM – general anesthesia + *iv* morphine.

Average consumption of *iv* morphine *via* PCA pump was 47.7 mg in the SAM group, and 48.8 mg in the GAM group. The amount of morphine used did not differ significantly between groups.

#### Side effects

Side effects, such as – nausea, urine retention, and episodes of hypotension were recorded in all groups. Data analysis showed the statistically high difference in the incidence of nausea among the groups, 4 h after the operation. In the GAM group, 60% of patients were found to have nausea, whereas the incidence of nausea in the CNB group was 46.7%. The lowest incidence of nausea was in the SAM group – 6.7%. ( $\chi^2 = 10.769$ ;  $p < 0.01$ ) (Table 3).

The incidence of nausea was also significantly different among the groups, 12 h after the operation. Episodes of nausea have been recorded in 46.7% of patients in the SAM group, while the incidence in other groups was lower, especially in the PNB group, where none of the patients had nausea ( $\chi^2 = 9.712$ ;  $p < 0.01$ ) (Table 3).

**Table 3**  
**Incidence of nausea in the patients 4 h and 12 h after the hip replacement**

Group	After 4 h		After 12 h	
	no	yes	no	yes
CNB	8	7	12	3
PNB	11	4	15	0
SAM	14	1	8	7
GAM	6	9	12	3
Total	39	21	47	13

**CNB – central nerve block (epidural); PNB – peripheral nerve block (lumbar plexus block); SAM – spinal anesthesia + intravenous (*iv*) morphine; GAM – general anesthesia + *iv* morphine.**

The incidence of nausea was around 5% in all groups 24 h after the operation and did not differ among them ( $\chi^2 = 1.053$ ;  $p > 0.05$ ).

In all studied groups, incidence of hypotension was not significantly different postoperatively, 4 h ( $\chi^2 = 3.057$ ;  $p > 0.05$ ), 12 h, ( $\chi^2 = 2.243$ ;  $p > 0.05$ ) and 24 h after the operation (0% in all groups). The incidence of hypotension varied from 6.7% (the SAM and the GAM group) to 33% (the CNB group) 4 h after the operation. The highest percentage of episodes of hypotension (20%) was also recorded in the CNB group 12 h after the operation. None of the patients from any group was hypotensive 24 h postoperatively. All these episodes of hypotension were successfully treated with boluses of phenylephrine 0.1 mg *iv* and *iv* administration of crystalloids.

The incidence of urine retention was significantly different 12 h after the operation. Urine retention was present only in the CNB group with incidence of 33.3%. ( $\chi^2 = 16.365$ ;  $p < 0.01$ ). However, incidence of urine retention did not differ significantly 4 h ( $\chi^2 = 2.342$ ;  $p > 0.05$ ) and 24 h ( $\chi^2 = 2.061$ ;  $p > 0.05$ ) after the operation, among the groups.

#### Discussion

Numerous clinical data suggest that acute pain after hip replacement is undermanaged and not treated adequately<sup>13</sup>. Most of the techniques for postoperative analgesia are advanced and need educated staff and expensive equipment. Due to the fact that hip replacement can cause moderate to severe pain relief, regional anesthesia techniques such as epidural and lumbar plexus block should be continued during the early postoperative period<sup>14,15</sup>.

Numerous types of peripheral blocks have been investigated as a tool for postoperative analgesia after hip replacement. A possible analgesic alternative to lumbar plexus block is continuous femoral nerve block (FNB). Marino et al.<sup>16</sup> compared patients after hip replacement with lumbar plexus catheters and continuous FNB. The lumbar plexus block group showed overall higher patient satisfaction scores during 24 h after the operation when compared to femoral nerve catheter group. Sensory block in the area of femoral nerve and lateral femoral cutaneous nerve appeared to be better in the lumbar plexus group, but the main difference was in the area of the obturator nerve. Our findings confirmed the results of Marino et al.<sup>16</sup>, and showed that the use of a continuous lumbar plexus block provided effective analgesia at rest and on moving during 24 h after primary hip arthroplasty.

On the other hand, Ilfeld et al.<sup>10</sup> demonstrated that, according to their results, continuous FNB may be a possible analgesic alternative to lumbar plexus block. The average pain scores for patients scheduled for total hip arthroplasty receiving a femoral infusion were 3.6 (1–8) vs patients who were administered a posterior lumbar plexus infusion, 3.5 (1–8). Patients with femoral infusion had a more dense motor block, and could not ambulate 24 h after surgery. Our data showed lower overall scores in the PNB group (lumbar plexus group), at rest 4 h postoperatively 1.47 (0-4), 12 h postoperatively 0.93 (0-3) and 24 h postoperatively 0.47 (0-1). A possible explanation is that lumbar plexus analgesia was started preoperatively, and a standard amount of local anesthetic was administered preemptively (20 mL levobupivacaine 0.25%). Therefore, immediately after the operation, all the patients had satisfactory analgesia (lower than 5 at VAS). Furthermore, the psoas compartment approach to the lumbar plexus is preferable for a surgery to the hip because it is the most proximal lumbar plexus technique, provides a complete block of the lumbar plexus, and the needle or catheter insertion site is distant from the surgical incision<sup>11</sup>.

In the study of Voloshin et al.<sup>17</sup> who observed the efficacy of acute pain service after joint arthroplasty, 1,343 patients subjected to hip arthroplasty with epidural postoperative analgesia were studied. Average pain intensity was 20 mm according to VAS. Meta-analysis of Choi et al.<sup>18</sup> compared postoperative lumbar epidural analgesia to other methods for postoperative pain relief. Results showed standardized mean differences (SMD) – 0.77 [95%, confidence interval (CI) 0.31–1.24], suggesting that during the first four to six hours after surgery, patients receiving epidural analgesia had less pain at rest, when compared to systemic analgesia. However, benefits may be limited to the early postoperative period. Our study also confirmed the superiority of epidural

analgesia following hip replacement in all studied groups. The epidural group showed minimal pain scores at rest 4 h after the operation ( $0.07 \pm 0.25$ ) and even no pain 12 h and 24 h after the hip replacement.

Some authors, e.g. Tetsunaga et al.<sup>19</sup> and Singelyn et al.<sup>20</sup> have not found a significant difference among different types of analgesia for hip replacement. According to these studies, quality of pain relief, postoperative hip rehabilitation, and duration of hospital stay were comparable in all groups (*iv* morphine, epidural analgesia and peripheral block). Our results have not been consistent with these studies when postoperative analgesia is in question. Both groups with systemic analgesia using morphine (the GAM and the SAM group), had the highest level of pain according to VAS. In the present study, epidural analgesia and peripheral block were started preoperatively, providing good quality of analgesia immediately after the operation. Because of the fact that preemptive analgesia decreases pain by preventing sensitization of pain pathways activated by operative trauma, the GAM group without any kind of intraoperative or postoperative regional technique had significantly higher pain scores.

Peripheral blocks have been shown to provide superior analgesia and fewer side effects when compared with parenteral opioids. Single shot peripheral blocks have limited duration of their analgesic effects. The introduction of continuous techniques using peripheral catheters enabled prolonged postoperative pain relief and reduction of opioid administration.

Marino et al.<sup>16</sup> investigated the mean pain scores on VAS, using lumbar plexus block or hydromorphone, at rest and during physical therapy (at 2 h, 24 h, and 48 h). According to their findings, pain scores were significantly lower in the continuous lumbar plexus block group [3.5 (95% CI, 3.0–4.0) and 2.6 (95% CI, 2.0–3.2), respectively] in comparison to the group that had opioid patient-controlled analgesia alone [6.4 (95% CI, 5.9–6.9) and 4.8 (95% CI, 4.3–5.3)] ( $p < 0.05$ ). The present study showed comparable results. Average pain scores at rest, 4 h and 24 h after the operation in the PNB group were  $1.47 \pm 1.24$  (95% CI; 0–4.0) and  $0.47 \pm 0.51$  (95% CI; 0–1.0), respectively. In the GAM group, where postoperative analgesia was maintained using PCA morphine, average scores recorded 4 h and 24 h after the operation were significantly higher ( $3.93 \pm 2.12$  and  $2.73 \pm 1.22$ , respectively).

Although hydromorphone is a morphine derivative, it is much more potent than morphine. The estimated relative potency of hydromorphone to morphine is 7.5 : 1. Overall consumption of hydromorphone in Marino's et al.<sup>16</sup> study was 9.4 (7.7–11.1) mg which could be equivalent to 70.5 mg of morphine. Our data showed average consumption of 48.8 (23–78) mg morphine, up to 24 h postoperatively in the GAM group and 47.7 (28–72) mg of morphine in the SAM group and confirmed that in the absence of adequate central or peripheral blockade, opioid use is significant for hip arthroplasty.

Meta-analysis of Chan et al.<sup>21</sup>, which included 45 eligible randomized controlled trials (RCT) compared FNB vs PCA opioid, epidural, local infiltration or oral analgesia for total knee arthroplasty. FNB group demonstrated a lower risk of nausea/vomiting [RR (Relative risk ratios) 0.63] and higher patient satisfaction (SMD 0.60), when compared with epidural analgesia group. Our study showed results consistent with the study of Chan et al.<sup>21</sup>, confirming that epidural group (the CNB group)

and the GAM group had a higher incidence of nausea when compared to the PNB group. Our results are also similar to study conducted by Jules-Elysee et al.<sup>22</sup> who found out significantly higher scores for nausea, vomiting, and itchiness in the epidural analgesia group ( $p < 0.05$ ).

A systematic review of Choi et al.<sup>18</sup> analyzed the differences between epidural analgesia and systemic analgesia after hip and knee replacement due to the frequency of nausea and vomiting. They did not find statistically significant difference between groups [odds ratio (OR) 0.95; 95% CI: 0.60–1.49]. However, retention of urine [OR 3.50, 95% CI: 1.63 to 7.51; number needed to harm (NNH) 4.5; 95% CI: 2.3 to 12.2] and low blood pressure (OR 2.78; 95% CI: 1.15–6.72; NNH 6.7; 95% CI: 3.5–103) were more frequent in epidural analgesia group, when compared to systemic analgesia. It is important to add that if low concentration epidural analgesia has been used likewise in our study, negative effects have been occurring less frequently. Different authors use different concentrations of local anesthetics with or without opioids for epidural analgesia. Study of Misiran et al.<sup>23</sup> has not found a significant number of complications such as hypotension, pruritus, sedation or motor block when a low dose concentration of ropivacaine or levobupivacaine has been used for postoperative epidural analgesia after major orthopedic surgery.

Tetsunaga et al.<sup>19</sup> compared side effects of continuous epidural analgesia, PCA with morphine and continuous three-in-one FNB on postoperative outcomes after total hip arthroplasty. They found the significantly lower incidence of nausea/vomiting in the peripheral block group ( $p < 0.05$ ). Our study showed the extremely low incidence of nausea in the PNB group. Twelve hours following surgery and later on, none of the patients had nausea in the PNB group. The difference was significant ( $\chi^2 = 9.712$ ;  $p < 0.01$ ), especially when compared with groups with postoperative use of opioids (SAM and GAM groups). Despite using opioids, the SAM group did not have a high incidence of nausea 4 h after the operation because of prolonged sensitive and motor block after spinal anesthesia. Therefore, patients did not use opioids via PCA device in early postoperative period.

Meta analysis of Richman et al.<sup>24</sup> included 19 studies with continuous peripheral nerve block or systemic opioids for pain control after extremity surgery without major complications. Patients who received opioid analgesia had opioid side effects more frequently, such as nausea/vomiting, sedation, and pruritus and the difference between groups was significantly higher ( $p < 0.001$ ). Our data also showed the superiority of peripheral block over other groups in the incidence of nausea, hypotension and urine retention.

Limitations of the study were a relatively low number of patients in each group, different types of intraoperative anesthesia and superposing of the medications given intraoperatively with postoperative analgesia few hours after the operation.

## Conclusion

Administration of postoperative analgesia using lumbar plexus block provides satisfactory analgesia with the low incidence of side effects when compared to epidural analgesia or parenteral opioids following hip arthroplasty.

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