

## Lumbar Plexus Block Reduces Pain and Blood Loss Associated with Total Hip Arthroplasty [Clinical Investigations]

Stevens, Robert D. M.D.\*; Van Gessel, Elisabeth M.D.†; Flory, Nicolas M.D.‡; Fournier, Roxane M.D.‡; Gamulin, Zdravko M.D.†

\*Research Fellow. †Staff Anesthesiologist. ‡Chief Resident.

Received from the Department of Anesthesiology, Pharmacology and Surgical Intensive Care, Hôpitaux Universitaires de Genève, Switzerland.

Address reprint requests to Dr. Stevens: Department of Anesthesiology, Pharmacology and Surgical Intensive Care, Hôpitaux Universitaires de Genève, 1211 Geneva 14, Switzerland. Address electronic mail to:

Robert.Stevens@hcuge.ch

### Abstract

**Background:** The usefulness of peripheral nerve blockade in the anesthetic management of hip surgery has not been clearly established. Because sensory afferents from the hip include several branches of the lumbar plexus, the authors hypothesized that a lumbar plexus block could reduce pain from a major hip procedure.

**Methods:** In a double-blind prospective trial, 60 patients undergoing total hip arthroplasty were randomized to receive general anesthesia with (plexus group,  $n = 30$ ) or without (control group,  $n = 30$ ) a posterior lumbar plexus block. The block was performed after induction using a nerve stimulator, and 0.4 ml/kg bupivacaine, 0.5%, with epinephrine was injected. General anesthesia was standardized, and supplemental fentanyl was administered per hemodynamic guidelines. Postoperative pain and patient-controlled intravenous morphine use were serially assessed for 48 h.

**Results:** The proportion of patients receiving supplemental fentanyl intraoperatively was more than 3 times greater in the control group (20 of 30 vs. 6 of 29,  $P = 0.001$ ). In the postanesthesia care unit, a greater than fourfold reduction in pain scores was observed in the plexus group (visual analogue scale [VAS] pain score at arrival  $1.3 \pm 2$  vs.  $5.6 \pm 3$ ,  $P < 0.001$ ), and "rescue" morphine boluses (administered if VAS  $> 3$ ) were administered 10 times less frequently (in 2 of 28 vs. in 22 of 29 patients,  $P < 0.0001$ ). Pain scores and morphine consumption remained significantly lower in the plexus group until 6 h after randomization (VAS at 6 h,  $1.4 \pm 1.3$  vs.  $2.4 \pm 1.4$ ,  $P = 0.007$ ; cumulative morphine at 6 h,  $5.6 \pm 4.7$  vs.  $12.6 \pm 7.5$  mg,  $P < 0.0001$ ). Operative and postoperative (48 h) blood loss was modestly decreased in the treated group. Epidural-like distribution of anesthesia occurred in 3 of 28 plexus group patients, but no other side-effects were noted.

**Conclusions:** Posterior lumbar plexus block provides effective analgesia for total hip arthroplasty, reducing intra- and postoperative opioid requirements. Moreover, blood loss during and after the procedure is diminished. Epidural anesthetic distribution should be anticipated in a minority of cases.

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TOTAL hip arthroplasty, one of the most frequently performed surgical procedures, generates significant postoperative pain that may be treated using regional anesthesia. When compared with other regimens, regional anesthesia provides superior pain relief and may favorably influence outcomes such as blood loss and thromboembolic events. [1](#) In the case

of major knee surgery, recent evidence suggests that early rehabilitation may be improved by use of regional anesthetic techniques. [2,3](#) Peripheral nerve blocks of the lower extremities, which offer many of the advantages of other types of regional anesthesia, are also reported to circumvent some of the drawbacks associated with these other types. [2–4](#) Regional blocks have thus gained acceptance for perioperative management of procedures on the knee and below, both as a complement to general anesthesia and as an alternative to centroneuraxial analgesia. For surgery of the hip, however, the role of peripheral nerve blockade needs to be defined.

Sensory innervation of the hip involves branches of the lumbar plexus (LP) and the sacral plexus. [5,6](#) Local anesthetic may be directed to the LP by an anterior approach called paravascular, or 3-in-1 block, [7](#) or by a posterior approach, of which several methods have been described. [8–10](#) The concept of the 3-in-1 technique as a plexus block is controversial because it does not consistently produce anesthesia of the obturator or lateral femoral cutaneous nerves. [11,12](#) Moreover, in a recent study of total hip arthroplasty, the benefit of 3-in-1 block in terms of reduced pain scores or opioid requirement was not clearly shown. [13](#)

Studies show that posterior LP techniques are reliable in their ability to block major LP branches. [11,14](#) Based on the observation that the LP innervates a significant portion of the hip region, we tested the hypothesis that an LP block would provide effective analgesia for total hip arthroplasty. Ancillary end points, such as blood loss, block side-effects and complications, postoperative nausea and vomiting, and patient satisfaction, were also assessed.

## Materials and Methods [↑](#)

After obtaining institutional review board approval and written informed patient consent, we conducted a randomized, controlled, double-blind trial of 60 consecutive patients undergoing elective total hip arthroplasty during general anesthesia. Exclusion criteria were contraindications to regional anesthesia, use of opioids during the preoperative period, and dementia preventing proper comprehension of the study.

Patients were randomly allocated to receive general anesthesia combined with an LP block (plexus group,  $n = 30$ ) or general anesthesia alone (control group,  $n = 30$ ). All patients were scheduled for surgery at 8:00 am. After premedication with 7.5 mg midazolam orally, general anesthesia was induced with 4–6 mg/kg sodium thiopental and 2  $\mu$ g/kg fentanyl and maintained with 0.3–1% isoflurane and 60–70% nitrous oxide. Tracheal intubation was facilitated with use of 0.2 mg/kg mivacurium and lungs were mechanically ventilated (end-tidal carbon dioxide, 30–38 mmHg [4 to 5 kPa]). Patients were placed in the lateral decubitus position, operative extremity superior. After recovery from use of mivacurium (as assessed by train-of-four stimulation of the ulnar nerve or by the appearance of respiratory efforts interfering with mechanical ventilation), patients assigned to the plexus group were administered a single-injection posterior LP block using the approach described by Winnie *et al.* [8](#) The LP was localized by inducing contractions of the quadriceps femoris with use of a nerve stimulator (DualStim; Life-Tech, Houston, TX), delivering 0.2–0.5 mA impulses of 50  $\mu$ s at 2 Hz linked to a 23-gauge, 100-mm sterile needle (Pole Needle; Top Corporation, Tokyo, Japan). After aspiration to ensure absence of blood or cerebrospinal fluid, 0.4-ml/kg bupivacaine, 0.5%, with epinephrine 1/200,000 was injected. In the control group, lumbar skin was perforated with use of a needle, but no placebo was administered. In conformity with the blinded study design, the anesthesiologist responsible for the patient was temporarily absent during treatment allocation, leaving the patient in the care of an attending anesthesiologist. The attending anesthesiologist administered the block when assigned, then transferred the patient to the initial staff. The surgical procedure was standardized and was performed with patients positioned as previously mentioned.

Intraoperatively, increments of vecuronium (1 mg) or mivacurium (2 mg) were administered only if warranted to facilitate the surgical procedure or mechanical ventilation. Hemodynamic goals were to maintain mean arterial pressure (MAP) and heart rate within 70–130% of preinduction or baseline levels. MAP increases to more than 130% of baseline were treated by raising end-tidal isoflurane to 1 vol% and administering boluses of fentanyl, 1  $\mu$ g/kg. A decrease in MAP to less than 70% of baseline was treated with ephedrine, 10 mg intravenously, followed by reduction of end-tidal isoflurane to 0.3%. In the postanesthesia care unit (PACU), a patient-controlled analgesia device was given to all patients and set to deliver intravenous morphine in 1-mg boluses, with a lockout at 6 min and a 4-h maximum of 40 mg. Patients in the PACU reporting pain greater than 3 on the VAS (0 = no pain, 10 = most severe pain) despite patient-controlled analgesia were administered boluses of intravenous “rescue” morphine as needed. In addition, all patients

received propacetamol, 2 g intravenously every 8 h administered shortly before the end of surgery and continued for 24 h, and ibuprofen, 400 mg orally every 8 h started on the morning after surgery.

Before selection for the study, a majority of study participants had been enrolled in an autologous blood transfusion program (plexus group, 24 of 30 patients; control group, 19 of 30 patients,  $P = 0.25$ ). Each patient pre-donated 2 to 3 units of blood during the weeks preceding surgery. In accordance with common practice at the Hôpitaux Universitaires de Genève, indications for perioperative autologous blood transfusions were not subject to specific guidelines.

Pain scores at rest and morphine consumption were assessed every 30 min in the PACU and then 6, 12, 24, and 48 h after randomization by observers who were blind to treatment allocation. Other recorded variables included intraoperative MAP, heart rate, and end-tidal isoflurane concentration; intraoperative opioid and muscle relaxant use; loss of blood, intraoperative (volume of blood measured in suction canisters and estimated from operative dressings [40 ml blood/dressing]) and postoperative (volume of blood recovered in suction drains before removal at 48 h); bilateral distribution of anesthesia, suggesting epidural spread (tested in the PACU with use of a cold stimulus applied to lower thoracic and lumbar dermatomes contralateral to the operated hip); evidence for block-related neurologic damage at 48 h; postoperative nausea or vomiting; and patient satisfaction with anesthetic and pain management (rated using VAS, 10 = very satisfied, 0 = very unsatisfied). All observations were made by blinded assessors.

### Statistical Analysis

Based on previous data, [13,15](#) it was computed that a sample of 30 patients/group would detect a difference between groups in mean morphine consumption of more than 20 mg and a difference in VAS pain scores of more than 1.7 cm, with a power of 90% and a two-tailed significance level of 5% ( $[\beta] = 0.1$ ,  $[\alpha] = 0.05$ ). In an analysis made after obtaining results and using other data, [16](#) it was calculated that a sample of this size had 90% power to detect a difference of 130 ml in mean operative blood loss. Where relevant, data are presented as the mean  $\pm$  SD. Comparisons between groups of continuous variables (MAP, end-tidal isoflurane concentration, morphine use, pain scores, satisfaction scores, blood loss) were assessed using the unpaired Student  $t$  test, whereas comparisons of discontinuous data (proportions of patients) were evaluated using the chi-square test.  $P < 0.05$  was considered to be significant. Some data were analyzed using StatMate and Prism software (GraphPad, San Diego, CA).

### Results

Preoperative characteristics were similar in the two groups ([table 1](#)). Two patients, one in each group, were excluded from analysis of postoperative data because of delirium, impeding accurate evaluation. One patient in the plexus group received a dose of local anesthetic incompatible with the study requirement and was excluded from intra- and postoperative analysis. Bilateral distribution of anesthesia, suggesting an epidural extension of local anesthetic, occurred in 3 of 28 (10.7%) patients undergoing the block.

**Table 1. Preoperative Characteristics**

	Plexus Group (n = 30)	Control Group (n = 30)
Age (yr)	66 ± 10	66 ± 10
Gender (M/F)	15/15	15/15
Weight (kg)	72 ± 14	72 ± 13
Height (cm)	166 ± 9	165 ± 8
Pain, resting (VAS)	2 ± 2	1.4 ± 2
Pain, walking (VAS)	6.5 ± 2	6.4 ± 2
ASA I/II/III	2/27/1	3/24/3
Arterial hypertension (n)	14	17

Values are ± SD.

ASA = American Society of Anesthesiologists physical status; VAS = visual analogue scale.

Table 1. Preoperative Characteristics Values are ± SD. ASA = American Society of Anesthesiologists physical status; VAS = visual analogue scale.

Data related to anesthetic and perioperative management are summarized in [table 2](#) and [figures 1 and 2](#). The number of patients requiring supplemental fentanyl and the mean end-tidal isoflurane concentration were significantly increased in the control group, whereas intraoperative MAP was lower in the plexus group during most of the procedure. These differences in MAP remained significant even when patients with epidural-type distribution were excluded from analysis ( $P < 0.01$  for the difference between groups in MAP from the twentieth to the sixtieth min of surgery, and  $P < 0.02$  for the difference between groups at the eightieth and ninetieth min). A reduction in blood loss was observed in the plexus group, during the surgical procedure (22% reduction in loss) and 48 h after (45% reduction). When patients who had epidural distribution were excluded from analysis, the intraoperative blood-sparing effect was not statistically significant (plexus group mean blood loss,  $434 \pm 196$  ml vs. controls,  $538 \pm 254$  ml;  $P = 0.09$ ), whereas the postoperative loss remained significantly lower ( $144 \pm 97$  ml vs.  $310 \pm 204$  ml,  $P = 0.0006$ ). Eight patients, four in each group, received a unit of autologous blood intraoperatively, and all remaining autologous units were transfused over the ensuing 48 h. No heterologous blood was administered.

**Table 2. Anesthetic and Perioperative Variables**

	Plexus (n = 29)	Control (n = 30)	P
Supplemental fentanyl (no. of patients requiring)	6	20	0.001
Supplemental muscle relaxants (no. of patients requiring)	18	21	0.2
Duration of surgery (min)	130 ± 16	132 ± 37	0.7
Blood loss (ml)			
Intraoperative	420 ± 187	538 ± 254	0.04
Postoperative (48 h)	170 ± 125	310 ± 204	0.003

Values are mean ± SD.

Supplemental = agents administered after the induction period (see text).

Table 2. Anesthetic and Perioperative Variables Values are mean ± SD. Supplemental = agents administered after the induction period (see text).

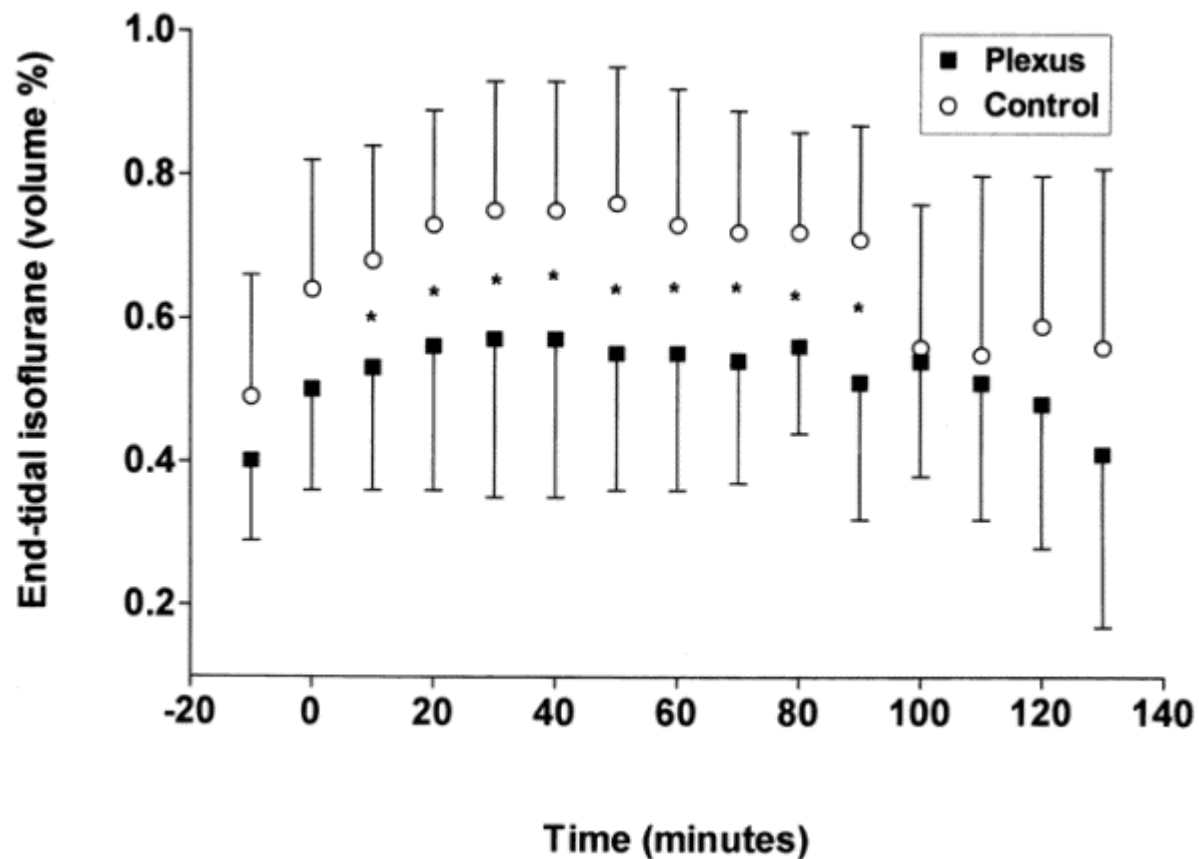


Fig. 1. Isoflurane administration is reduced in patients undergoing lumbar plexus block (plexus). Values are mean  $\pm$  SD. Zero on the time scale marks the beginning of surgery. \* $P \leq 0.001$  for differences between groups.

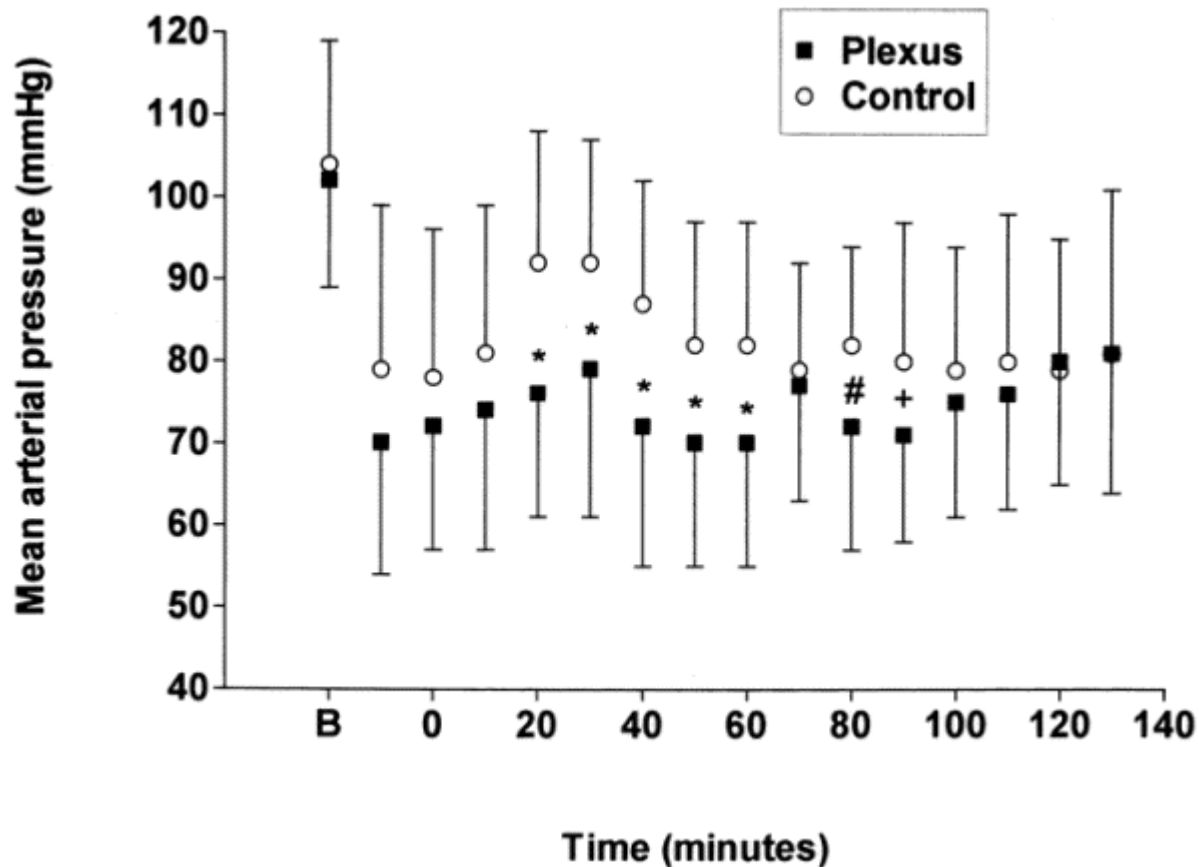


Fig. 2. Intraoperative mean arterial pressure is decreased in patients who underwent a lumbar plexus block (plexus). Values are mean  $\pm$  SD. On time scale, B refers to baseline mean arterial pressure recorded before induction of anesthesia, and 0 marks the beginning of surgery. \* $P \leq 0.005$  for differences between groups; # $P = 0.01$ ; and + $P = 0.03$ .

Pain scores were significantly reduced in the plexus group until 6 h after randomization (VAS at 6 h,  $1.4 \pm 1.3$  vs.  $2.4 \pm 1.4$ ,  $P = 0.007$ ). Differences in pain scores were particularly evident in the immediate postoperative period (fig. 3). Therefore, at arrival to the PACU, 18 of 28 patients in the plexus group reported no pain (VAS = 0) versus 3 of 29 in the untreated control group ( $P < 0.0001$ ). Conversely, at this same time point, 17 of 29 control patients had severe pain (VAS > 5), versus 2 of 28 of treated patients ( $P < 0.0001$ ). Morphine administration, including patient-controlled analgesia and rescue doses, was diminished to a significant degree in the treated group until 6 h after randomization (cumulative morphine at 6 h,  $5.6 \pm 4.7$  vs.  $12.6 \pm 7.5$  mg,  $P < 0.0001$ ), with a trend toward reduced consumption at 12 h (fig. 4). Only 2 of 28 patients required rescue morphine in the plexus group, versus 22 of 29 among controls ( $P < 0.0001$ ).

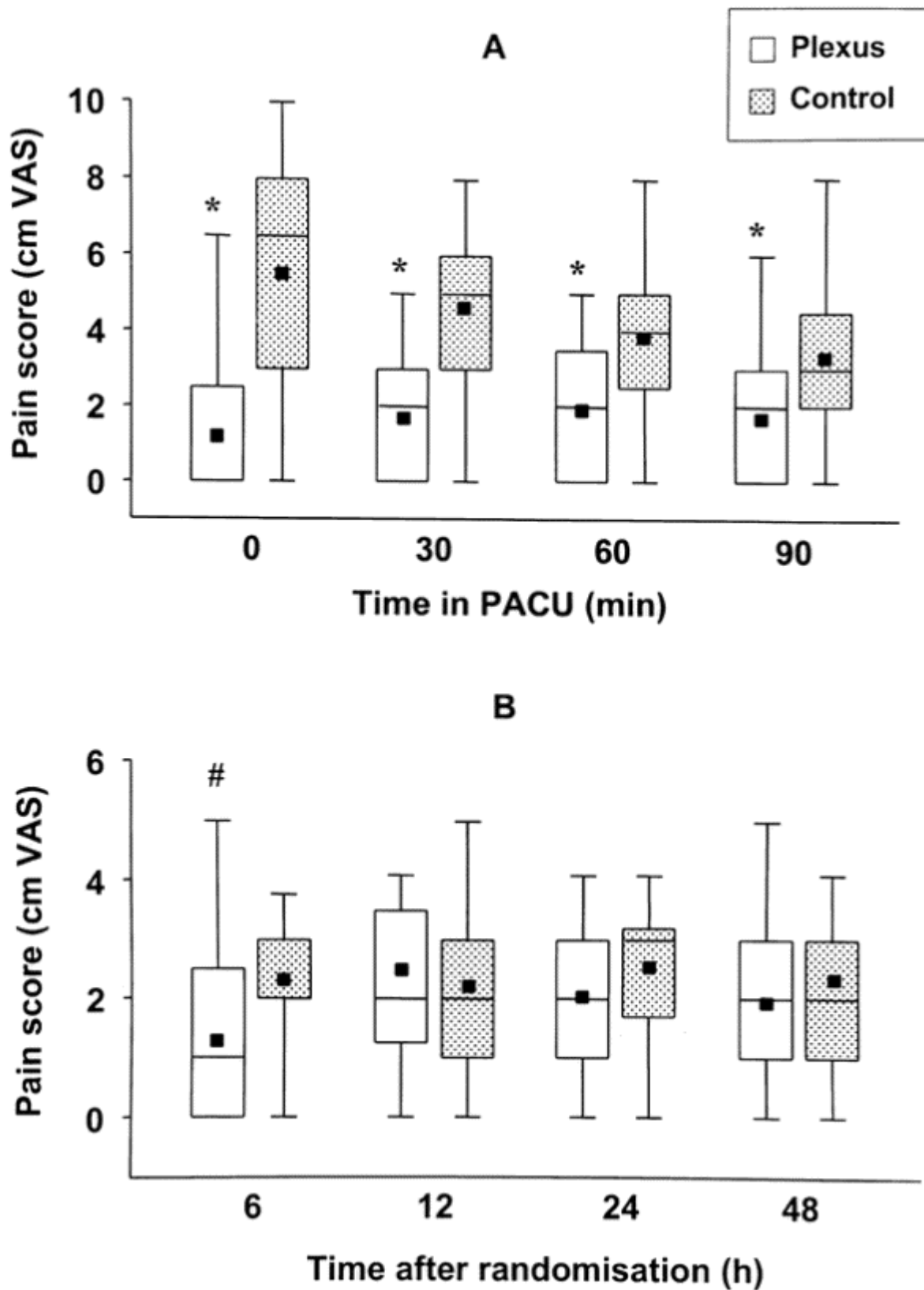


Fig. 3. Postoperative pain scores. (A) Pain scores in the postanesthesia care unit (PACU). (B) Pain scores in the wards. Upper and lower sides of boxes represent twenty-fifth and seventy-fifth percentiles, horizontal lines inside boxes are medians, shaded squares are means, and error bars represent ranges. \* $P < 0.001$  and # $P = 0.007$  for differences between group means.

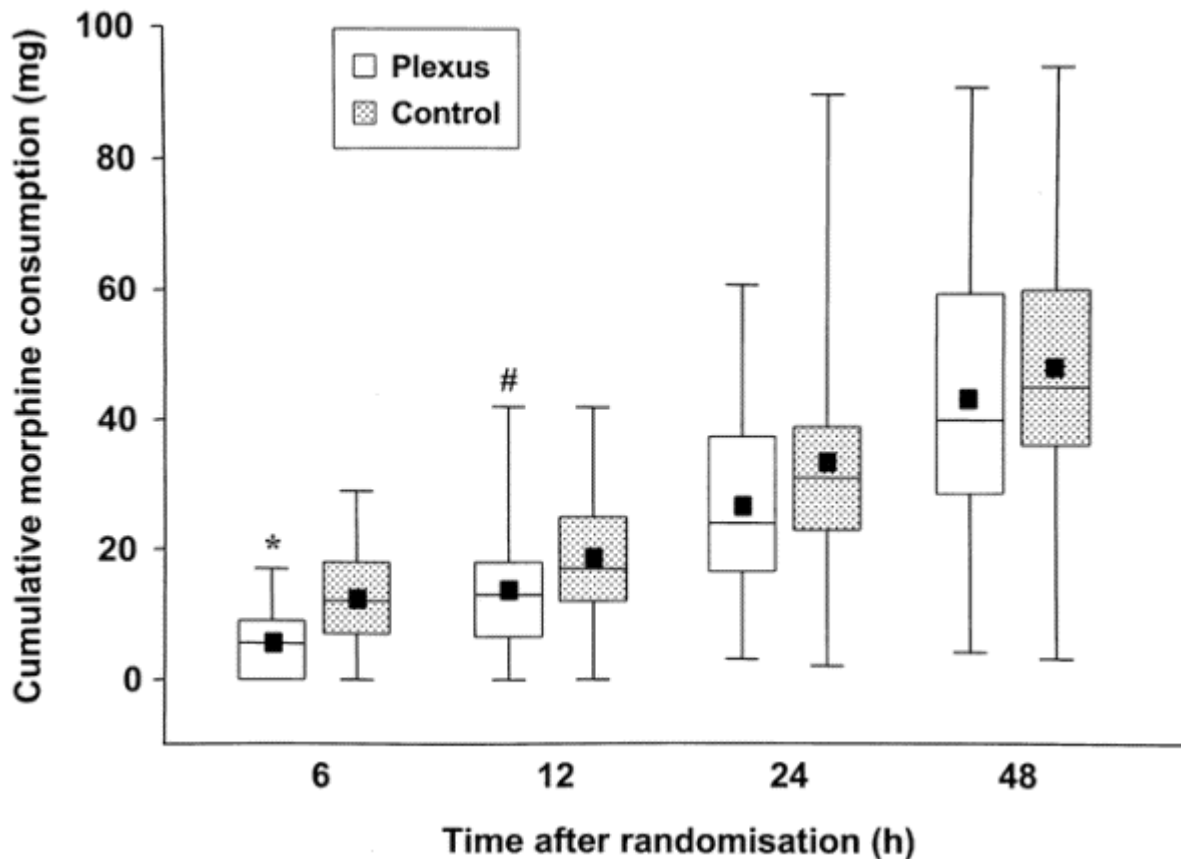


Fig. 4. Patients who underwent lumbar plexus block (plexus) use significantly less morphine in the early postoperative period. Cumulative morphine includes patient-controlled analgesia and rescue doses. Upper and lower sides of boxes represent twenty-fifth and seventy-fifth percentiles, horizontal lines inside boxes are medians, shaded squares are means, and error bars represent ranges. \* $P < 0.0001$  and # $P = 0.05$  for differences between group means.

Postoperative nausea and vomiting occurred in a minority of patients, and the incidence was similar in both groups. No other side-effects or complications were noted. Patient satisfaction with anesthetic and pain management was not significantly different between the two groups.

## Discussion

Our results show that posterior LP block successfully reduces pain associated with total hip arthroplasty, decreasing intra- and early postoperative opioid requirements. Another interesting finding was a block-associated reduction in hemorrhage.

Peripheral nerve or plexus blocks, with or without perineural catheter placement, constitute an attractive option for anesthetic management of lower limb surgery, either substituting for or complementing other anesthetic techniques. Blocks are appreciated for the superlative and long-lasting analgesia they provide; moreover, when compared with other types of anesthesia, nerve blocks may enhance intraoperative hemodynamic stability, [4,17](#) decrease risk of urinary retention, [3,18](#) reduce risk of puncturing the dura mater, and diminish surgical blood loss. [16](#)

The LP is formed by the ventral rami of the first four lumbar roots, with a contribution from the twelfth thoracic root. These elements converge in the posterior part of the psoas muscle and produce seven to eight branches, all of which contribute to a varying degree to the sensory innervation of the hip region. [5](#) The hip joint is innervated by branches of both the LP and the sacral plexus, including the femoral (L2–L4) and obturator nerves (L2–L4), which contain afferents from the anteromedial aspects of the joint, and the sciatic nerve (L4–S3), the nerve to the quadratus femoris (L4–S1) and

the superior gluteal nerve (L4–S1), which cover the posterior aspect of the joint. [5,6](#) Although the relative contributions of lumbar and sacral components to sensory innervation are not known, our results suggest that local anesthetic blockade of the LP is sufficient to provide effective analgesia early after total hip arthroplasty. Although this finding is in itself of interest, we predict that its clinical relevance will be further shown by the application of continuous catheter-based techniques, as indicated in a recent preliminary report. [19](#)

Lumbar plexus blocks were developed by Winnie *et al.*, who described both an anterior [7](#) and a posterior [8](#) technique. The anterior, or 3-in-1, approach was based on the hypothesis that a large volume of local anesthetic placed in the femoral nerve sheath would spread proximally to the LP and block other branches, including the obturator and lateral femoral cutaneous nerves. Although the original account supported this postulate, subsequent reports failed to show reliable blockade of obturator or lateral femoral cutaneous nerves with use of this technique, and the concept of the 3-in-1 technique as a plexus block is contested. [11,12](#) With the posterior LP approach, local anesthetic is deposited within or adjacent to the dorsal portion of the psoas muscle. Several methods of performing the posterior LP block have been described, [8–10](#) all of which consistently produce anesthesia of LP branches important to lower limb surgery. In addition, some authors using posterior techniques have noted simultaneous anesthesia of lumbar and sacral plexi, [8,20](#) whereas others have not. [11,14](#)

Few studies have addressed the clinical interest of peripheral nerve or plexus blocks for surgery of the hip. Using a posterior LP technique, Chayen *et al.* [9](#) reported successful anesthesia in 52 of 57 hip procedures, but recommended combining lumbar and sciatic blocks in this indication. In a trial that compared general anesthesia alone or combined, either with subarachnoid block or with posterior LP block for femoral neck fracture surgery, White and Chappell [17](#) noted greater cardiovascular stability in the group receiving the block; but provided no data regarding other outcomes, such as postoperative analgesia. In a study of hip replacement, Odoom *et al.* [21](#) compared bupivacaine with or without epinephrine in a posterior LP block and noted lower peak bupivacaine concentrations and a prolongation of mean analgesia in the epinephrine group. Dalens *et al.*, [20](#) reporting a pediatric population of which 9 of 50 children underwent hip arthrotomies, contrasted posterior LP block performed according to the techniques of Winnie *et al.* [8](#) or Chayen *et al.*, [9](#) noting lumbosacral anesthetic distribution in the former group and bilateral or epidural-like distribution in the latter, without providing information about pain or analgesia. Finally, Fournier *et al.* [13](#) compared general anesthesia combined with 3-in-1 block *versus* general anesthesia alone for total hip arthroplasty and observed a longer opioid-free interval after surgery in the block group, although intraoperative use of opioids and isoflurane was not influenced by the block. Contrasting these results and ours suggests that the posterior LP block, by providing more extensive anesthetic coverage of the region, may be better suited to surgical procedures of the hip than is the 3-in-1 approach.

The decreased blood loss we report, intraoperatively and postoperatively, confirm the findings of Twyman *et al.*, [16](#) although only intraoperative loss was significantly reduced in that study. The clinical importance of this hemorrhage-sparing effect in terms of transfusion requirements was not directly addressed in the current study because most patients predonated blood for which transfusion policy was not guideline-directed, prohibiting a proper statistical comparison between groups. Diminished hemorrhage has been documented with various regional anesthetic techniques, including spinal and epidural anesthesia, [1](#) and is thought to result from attenuated sympathetic tone in medium and small vessels, with concomitantly reduced arterial and venous pressure. Two distinct mechanisms may influence blood loss in patients undergoing peripheral nerve block: a direct effect on vasoconstrictive sympathetic fibers contained in peripheral nerves and an indirect effect mediated by antinociception and reduced systemic blood pressure. In this regard, we noted lower intraoperative MAP in the plexus group ([fig. 2](#)). Because this difference was observed in the presence of equivalent baseline MAP measurements and similar prevalence of treated arterial hypertension in the two groups, with lesser administration of isoflurane and fentanyl in the plexus group, we suggest that it is attributable to attenuated nociception and autonomic arousal in the block-treated patients. Finally, lower intraoperative blood loss in the plexus group may be related to epidural-like blockade appearing in some of these patients.

In 3 of 28 patients in the plexus group, bilateral distribution of anesthesia developed, evoking spread of local anesthetic to the epidural space. Hypotension or extension of block to the upper thoracic dermatomes did not develop in any of these patients. Epidural extension of anesthesia is a known side effect of posterior LP block, occurring in 3–10% of adult patients without adverse consequences. [9,11,14](#) Notwithstanding, we believe that this result should be systematically checked after posterior LP block has been performed. Reported complications of posterior LP block, such

as total spinal anesthesia, [22](#) renal subcapsular hematoma, [23](#) and psoas hematoma with lumbar plexopathy, [24](#) were not observed in this trial.

The strengths of this study include the fact that it was designed to detect targeted differences between groups in the two major end points (pain, morphine use). A *post hoc* analysis showed that the trial also was sufficiently powered to detect observed differences in an ancillary end point: blood loss. Among the limitations, we noted that, although care was taken to ensure the double-blind design, observations such as asymmetric thigh mobility, epidural blockade, or decreased opioid requirements might have introduced bias among patients and data collectors.

In summary, LP block performed using a posterior approach is an effective complement to anesthetic and analgesic management of total hip arthroplasty, reducing opioid administration and blood loss during the surgical procedure and in the early postoperative period. Future studies should address the possibility of extending the duration of this benefit in the postoperative period, namely *via* continuous catheter-based techniques. Studies are also needed to confirm reduced bleeding in the setting of peripheral nerve blockade and to explore the clinical importance of this effect.

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