Continuous Three-in-One Block for Postoperative Pain After Lower Limb Orthopedic Surgery: Where Do the Catheters Go?

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Continuous three-in-one block is widely used for postoperative analgesia after proximal lower limb surgery, but location of the catheter has not been well addressed in the literature. We prospectively studied, in 100 patients, the characteristics of catheter threading under the iliac fascia and the correlations between catheter tip location and effective sensory and motor blockade of the three principal nerves of the lumbar plexus. Postoperatively, in conscious patients, 16 to 20 cm of a catheter was placed in the fascial sheath after femoral nerve location with a nerve stimulator. Contrast media (3 mL Iopamidol 390®) was injected, and the catheter tip was located by means of an anteroposterior pelvic radiograph. An equal-volume mixture of 0.5% bupivacaine/2% lidocaine with epinephrine (30 mL) was injected through the catheter. Patient and catheter-insertion characteristics were noted. Thirty minutes after injection, sensory blockade was evaluated in the cutaneous territories of the lateral femoral cutaneous, femoral, and obturator nerves, along with motor blockade of the last two nerves. Pain scores at 30 min were also recorded. Seven block failures were noted. The tip of the catheter reached the lumbar plexus (Group 1) in 23% of the patients and lay deep to the medial (Group 2) or lateral (Group 3) part of the fascia iliaca in 33% and 37% of the patients, respectively. Demographic data and catheter threading characteristics were comparable among the groups. A three-in-one block was noted in 91% of Group 1 patients, but in only 52% and 27% of Group 2 and 3 patients, respectively ($P < 0.05$). Comparing Group 2 and 3 patients, sensory block was achieved in respectively 100% and 94% for the femoral nerve, 52% and 94% for the lateral femoral cutaneous nerve ($P < 0.05$), and 82% and 27% for the obturator nerve ($P < 0.05$). Visual analog scale pain scores on movement were significantly lower in Group 1 patients ($P < 0.05$). We conclude that during a continuous three-in-one block, the threaded catheter rarely reached the lumbar plexus. The quality of sensory and motor blockade and initial pain relief depend on the location of the catheter tip under the fascia iliaca.

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The use of peripheral nerve blocks is recommended after orthopedic surgery (1). Continuous peripheral nerve blocks improve postoperative analgesia, patient satisfaction, and rehabilitation compared with IV narcotic therapy for both upper (2,3) and lower extremity procedures (4–6). For analgesia after proximal lower limb orthopedic surgery, continuous three-in-one nerve blockade is as effective as epidural analgesia, with fewer side effects (urinary retention, nausea, and risk of spinal subarachnoid hemorrhage in anticoagulated patients) (4,5).

Several groups have reported continuous lumbar-plexus (7,8) or three-in-one block (5,9,10) by means of continuous postoperative infusion of local anesthetics without radiographic evidence that they have positioned the catheter near the lumbar plexus. Ganapathy et al. (6) obtained computed tomography (CT) scans in 20 patients who were undergoing continuous three-in-one block. They found that only 40% of the catheters were in the position "ideal" (catheter tip located within 2 cm of the cephalad extremity of the sacroiliac joint or between the sacral promontory and the lateral aspect of L4 and L5 vertebral bodies). The authors of that study were not able to correlate the position of the catheter with successful blockade of the femoral, obturator, or lateral femoral cutaneous (LFC) nerve because only 20 of 62 patients in the study had CT scans. Nonetheless, in 80% of the patients who underwent

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CT, the catheter was placed in the intended zone, and three-in-one blockade was indeed obtained. Furthermore, the obturator nerve, which has sensory branches for the hip and knee (11), is not consistently attained by the local anesthetic solution during three-in-one block (12–16). These results may explain the absence of interest in the continuous three-in-one block analgesic technique expressed by some authors (17,18).

No published study has investigated the position of catheters under the iliacus fascia after a so-called continuous three-in-one block or the correlation between catheter position and sensory blockade of the three principal nerves of the lumbar plexus. The aim of this study was to evaluate the characteristics of catheter threading under the inguinal ligament and to correlate the catheter position with the rate of effective sensory and motor blockades of the three principal nerves of the lumbar plexus.

Methods

One-hundred consecutive ASA physical status I and II adults were included in this study once institutional approval and written, informed patient consent were obtained. The patients were scheduled to undergo hip, femoral shaft, or knee surgery. The postoperative pain management program included a continuous three-in-one block for all patients. All patients were orally premedicated with 0.1 mg/kg midazolam. Intraoperative general anesthesia was induced for all patients with 3 mg/kg IV propofol and 0.5 μg/kg sufentanil. Patients underwent endotracheal intubation or laryngeal mask airway insertion, and controlled ventilation was applied for the duration of surgery. Anesthesia was maintained with 60% nitrous oxide in oxygen, 0.75%–1.25% isoflurane end-tidal concentration, and 0.3 μg/kg IV sufentanil given over 45 min, followed by a 0.10 $\mu g \cdot kg^{-1} \cdot h^{-1}$ continuous infusion, which was stopped 30 min before the end of surgery.

After the surgical procedure, once the patients were awakened and tracheally extubated, the three-in-one blocks were performed by four senior anesthesiologists by using a nerve stimulator for precise nerve location (Stimuplex®; Braun, Melsungen, Germany). The landmarks of Winnie et al. (19) were used. With patients in the supine position, the femoral artery was located below the inguinal ligament, and an insulated short-beveled needle with an 18-gauge cannula (Mini Set®; Pajunk, Geisingen, Germany) was inserted 1 cm distal to the inguinal ligament and 0.5 cm lateral to the artery. With a starting output of 2 mA (frequency 1 Hz and time 100 μs), the needle was advanced cranially in a sagittal plane at a 30° angle to the skin until quadriceps femoris muscle twitches were elicited (i.e., cephalad patellar movement). The position was judged adequate when quadriceps contractions were still elicited at 0.5 mA. The femoral nerve sheath was distended with 5 mL of saline, and a 20-gauge multiperforated catheter was then threaded 16 to 20 cm under the iliaca fascia. The ease of insertion of the catheter (yes, easy; no, difficult) and the length of the catheter under the skin were recorded.

Contrast medium (30 mL Iopamidol 300®; Shering Pharmaceutical, Lys-Lez-Lannoy, France) was injected into the catheter, and an anteroposterior radiograph of the pelvic region was taken within 5 min. The radiographs were interpreted by two blinded physicians, one of whom was a radiologist. On the basis of the catheter tip location, patients were separated into three groups. In Group 1, designated the Lumbar Plexus group, the distal tip of the catheter was located between the sacral promontory and the lateral border of the bodies of L3 to L5 (Fig. 1A). In Group 2, designated the Medial group, the catheter tip was located under the psoas muscle fascia (Fig. 1B). In Group 3, designated the Lateral group, the catheter tip was located under the iliacus muscle fascia (Fig. 1C). An equal-volume mixture of 2% lidocaine with 1:200,000 epinephrine and 0.5% bupivacaine 30 mL was then injected via the catheter over a 2-min period. The arterial blood pressure was evaluated at 3-min intervals, and electrocardiographic tracings, respiratory rate, pulse oxymetry, and end-tidal CO_2 were monitored continuously during the procedure.

Sensory blockade was evaluated by using cold (ether on a cotton ball) and pain (pinprick) perception tests at 30 min after injection. Testing was performed on the sensory distribution of the femoral (anterior aspect of the thigh), LFC (lateral aspect of the thigh), and obturator (medial and posterior aspect of the knee) nerves (11). Motor blockade was evaluated at 30 min by testing the cephalad ascension of the patella (i.e., femoral nerve) and the muscular contraction of the adductor longus (i.e., obturator nerve). The results of the sensory and motor tests were reported as either yes (presence of a total sensory or motor blockade) or no (partial or absent sensory or motor blockade) for a given nerve territory. A block failure was defined by the absence of sensory block in each nerve skin territory. Pain on movement (knee or hip flexion with a 50° angle) was evaluated at 30 min after injection with a visual analog scale (VAS) ranging from 0 (no pain) to 100 mm (worst imaginable pain). All adverse effects were noted. General adverse effects, including arterial hypotension, sedation, urinary retention, and dysesthesia, were distinguished from local adverse effects, which included hematoma and catheter occlusion and kinking. Propacetamol (2 g three times daily) was administered IV over a 15-min period to all patients at the end of the surgical procedure. If, at 30 min, pain control was considered insufficient (VAS ≥40 mm), a

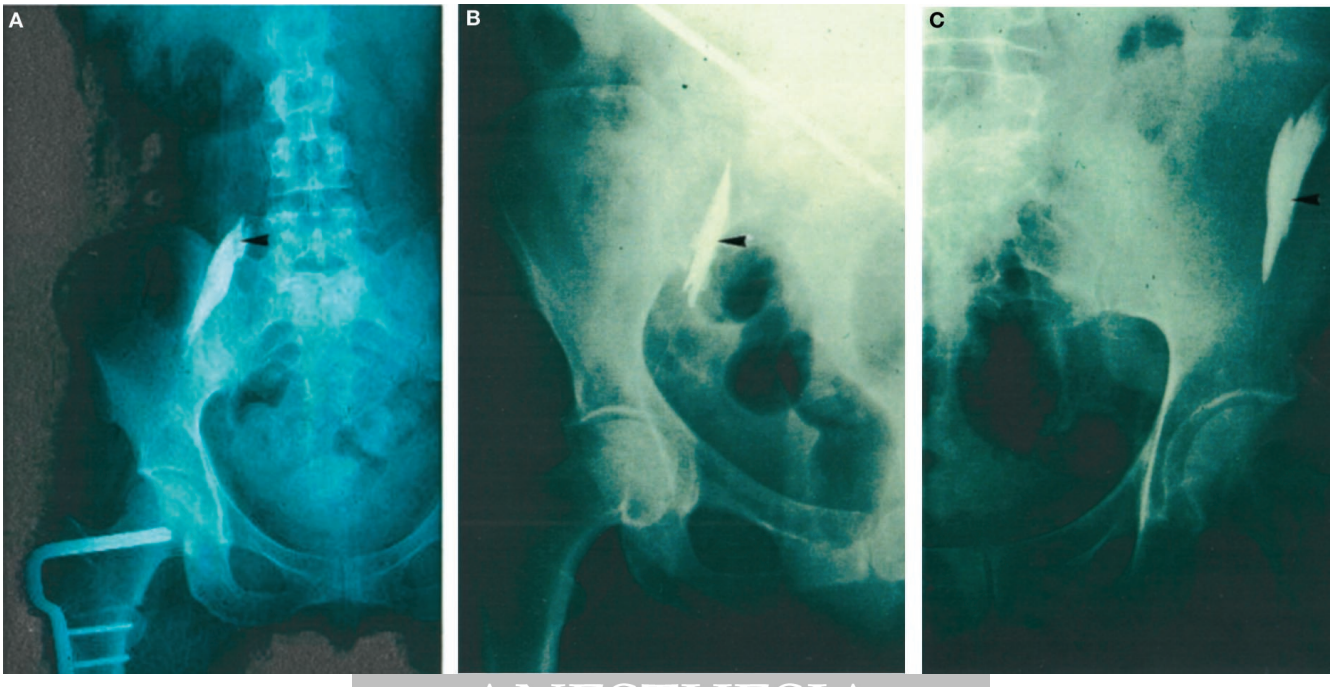

Figure 1. Frontal radiographs of the pelvic region showing the location of the catheter tip (arrows) and the spread of the 3 mL of contrast media. (A) The tip of the catheter was located between the sacral promontory and the lateral borders of the vertebral bodies of L3-5. (B) The tip was located under the iliac fascia covering the psoas major muscle. (C) The tip was located under the iliac fascia covering the iliacus muscle.

subcutaneous injection of morphine (0.1 mg/kg) was administered as rescue analgesia.

Statistical analysis was performed by using SAS version 6.11 software (SAS Institute, Cary, NC). The quantitative anthropometrics, catheter-insertion, and surgery data were expressed as mean ± SD. Pain scores were expressed as medians (25th–75th percentiles). Comparisons between groups were performed with the Mann-Whitney *U*-test for nonparametric data, and the χ^2 test was used for categorical data. A significance threshold of $P < 0.05$ was retained.

Table 1. Demographics, Length, and Ease of Catheter Insertion in the Three Groups

Variable	Group 1 (n = 23)	Group 2 (n = 33)	Group 3 (n = 37)
Sex ratio (M/F)	13/10	19/14	23/14
Age (yr)	54 ± 16	59 ± 13	57 ± 17
Height (cm)	168 ± 9	171 ± 11	167 ± 10
Weight (kg)	79 ± 11	73 ± 14	72 ± 9
Duration of surgery (min)	121 ± 37	117 ± 47	133 ± 39
Length of insertion (cm)	17.4 ± 2.1	16.3 ± 1.7	17.5 ± 2.5
Ease of insertion (Y/N)	18/5	27/6	29/8

Group 1 = catheter tip location near the lumbar plexus; Group 2 = catheter tip location under the psoas muscle fascia; Group 3 = catheter tip location under the iliacus muscle fascia.

Results

Seven patients had no sensory or motor blockade. Radiographs of these seven patients showed the distal tip of the catheter near the iliac crest in four, in the sartorius muscle in one, in the adductor longus muscle in one, and under the fascia of the abdominal muscles in one. Further analysis was performed in the remaining 93 patients. The plain films showed that 23 of the catheters reached the lumbar plexus area (Group 1, Fig. 1A). Thirty-three of the catheters coursed medially under the psoas muscle fascia (Group 2, Fig. 1B), and 37 coursed laterally under the iliacus muscle fascia (Group 3, Fig. 1C). Demographic data are presented in Table 1. No differences among groups were noted concerning sex ratio, age, weight, height, duration of surgery, the number of catheters in the group considered easy or difficult to insert, or the length of insertion. The type of surgery for each group is shown in Table 2. There was no difference among the groups regarding type of surgery.

The assessment of the efficacy of sensory blockade in the distribution of the femoral, LFC, and obturator nerves for each group of patients is shown in Table 3. Statistically significant intergroup differences were noted concerning the sensory blockade. In the Lumbar Plexus group, 91% of the patients had successful three-in-one block. The difference was significant ($P < 0.05$) with respect to the patients in Group 2 (52% had successful three-in-one block), in whom sensory blockade failure primarily involved the LFC nerve. Significantly more Group 1 patients

Table 2. Surgical Indications in the Three Groups

Variable	Group 1 (n = 23)	Group 2 (n = 33)	Group 3 (n = 37)
Total hip replacement	3	4	3
Dynamic hip screw	2	2	4
Femoral osteotomy/fracture	4	6	6
Cruciate ligament repair	7	8	9
Fracture of the patella	2	3	4
Total knee replacement	5	10	11

Group 1 = catheter tip location near the lumbar plexus; Group 2 = catheter tip location under the psoas muscle fascia; Group 3 = catheter tip location under the iliacus muscle fascia.

had completely successful three-in-one block than Group 3 patients ($P < 0.05$), in whom the obturator nerve was anesthetized in only 27%. Similarly, the motor obturator nerve block (Table 3) was successful in 74% of the patients of Group 1, versus 48% of the patients in Group 2 and 22% of the patients in Group 3 ($P < 0.05$). Finally, when comparing motor and sensory blockades for a given nerve, significant differences were noted concerning the obturator nerve in Groups 2 and 3 ($P < 0.05$).

The VAS scores during movement at 30 min after injection are presented in Figure 2. The Group 1 patients had lower pain scores (median, 10 mm; range, 10–25 mm) than Group 2 patients (median, 20 mm; range, 10–35 mm) or Group 3 patients (median, 20 mm; range, 10–40 mm) ($P < 0.05$).

Adverse effects of the nerve block included hematoma at the point of puncture in two patients and paresthesiae in the quadriceps femoris for 12 h in two patients. No patient had clinical evidence of local anesthetic toxicity. The incidence of nausea and vomiting was similar among the three groups.

Discussion

In this study we demonstrated that during insertion of a catheter for continuous three-in-one block the course of the catheter was totally unpredictable. Only 23% of the catheters were in the ideal position with the tip near the lumbar plexus. Moreover, there was no correlation between the final position of the catheter tip and the difficulty of positioning or the catheter length that was inserted. Most important, the percentages of successful sensory and motor blocks of the lumbar plexus nerves and the quality of postoperative analgesia depended on the position of the catheter under the fascia iliaca. Placement of the catheter tip near the lumbar plexus was necessary for optimal results of continuous three-in-one block.

The unpredictable position of the tip of the catheter in our study confirmed the findings of Ganapathy et al. (6) who found no correlation between the position of the fascia iliaca catheter shown by CT scan in 20 patients and the length or ease of insertion. Ganapathy et al. (6) reported that only 40% of the patients had the catheter tip in the appropriate zone near the lumbar plexus. In the same manner as local anesthetic solution injected under the fascia iliaca (15,16), catheters tend to course medially in the direction of the psoas muscle or laterally in that of the iliacus muscle instead of toward the lumbar plexus. Increasing the length of insertion to attempt to reach the lumbar plexus is inadvisable because the catheter may kink if it courses toward the fascia iliaca (6) or may lodge near the iliac crest, leading to failure of blockade. If the tip courses toward the lumbar plexus, there is a risk of epidural anesthesia, a case of which has been reported after a catheter insertion of 24 cm (20).

It is important to note that the percentages of sensory and motor blockade of the three primary nerves of the lumbar plexus depended on the location of the catheter tip. Successful three-in-one block was observed in 91% of the patients in whom the tip of the catheter was in the lumbar plexus area. This percentage decreased to 52% when the catheter tip was positioned medially under the fascia iliaca (deficient sensory blockade principally involving the LFC nerve) and to only 27% when the catheter was positioned laterally (deficient blockade of the obturator nerve). This finding, previously reported in the literature for the single-shot three-in-one block (12–15), emphasizes that the local anesthetic solution passes under the fascia, providing multiple-nerve trunk blockade. There is no anatomical fascial sheath capable of conveying a local anesthetic solution or a catheter from below the inguinal ligament to the lumbar plexus. Therefore, the spread of local anesthetic to the three nerves is difficult to obtain. Although the local anesthetic injected via the catheter can course far enough under the fascia iliaca to block the femoral nerve and the LFC nerve from a lateral position, it does not reach the obturator nerve from a medial position in sufficient quantities to obtain nerve blockade (21).

The obturator nerve courses along the medial edge of the psoas major muscle, distinct from the muscle plane in which the femoral and LFC nerves lie (22), and emerges from its medial border near the sacral promontory. From there, the obturator nerve courses behind the pelvic fascia behind the common iliac vessels and lateral to the hypogastric vessels. It enters the thigh through the upper part of the obturator foramen and divides into an anterior and a posterior branch. At this level, terminal branches of the nerve may anastomose with the saphenous nerve (11,23).

Given this trajectory, local anesthetics from a catheter placed near the lumbar plexus or medially under the fascia iliaca can reach the obturator nerve cephalad to its passage through the pelvis. This would explain the superior three-in-one blocks in patients in whom the catheter was in these positions. A sensory block of

Table 3. Sensory and Motor Blockade 30 Minutes After Local Anesthetic Injection in the Three Groups

Group	Three-in-one	Sensory blockade			Motor blockade	
		F	LFC	Obt	F	Obt
Group 1 (n = 23)	21/23 (91%)	23/23 (100%)	23/23 (100%)	21/23 (91%)	21/23 (91%)	17/23 (74%)
Group 2 (n = 33)	17/33 (52%)*	33/33 (100%)	17/33 (52%)*	27/33 (82%)	29/33 (88%)	16/33 (48%)*‡†
Group 3 (n = 37)	10/37 (27%)*‡	35/37 (94%)	35/37 (94%)‡	10/37 (27%)*‡	33/37 (89%)	8/37 (22%)*†‡

Group 1 = catheter tip location near the lumbar plexus; Group 2 = catheter tip location under the psoas muscle fascia; Group 3 = catheter tip location under the iliacus muscle fascia.
F = femoral nerve; LFC = lateral femoral cutaneous nerve; Obt = obturator nerve.
* $P < 0.05$ versus Group 1; † $P < 0.05$ versus sensory blockade for the same nerve; ‡ $P < 0.05$ versus Group 2.

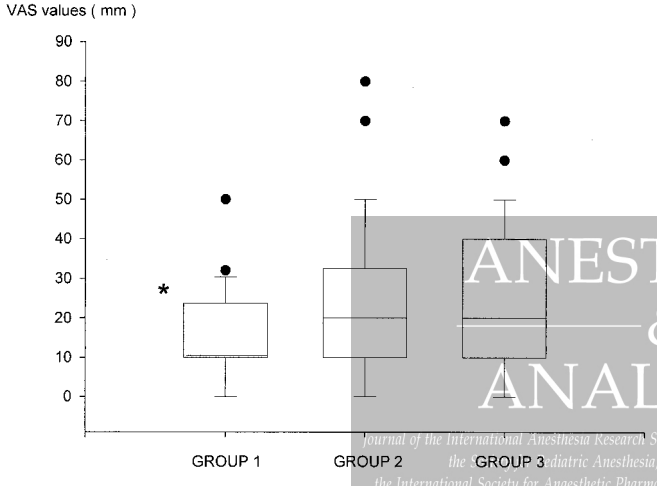

Figure 2. Comparison of the visual analog scale (VAS) values of pain on movement in the three groups at 30 min. The box represents the 25th–75th percentiles. The dark line is the median. The extended bars represent the 10th–90th percentiles, and the dark circles represent the values outside this range. * $P < 0.05$ versus Groups 2 and 3. Group 1 = catheter tip location near the lumbar plexus; Group 2 = catheter tip location under the psoas muscle fascia; Group 3 = catheter tip location under the iliacus muscle fascia.

the anterior branch of the obturator nerve by medial spread of local anesthetic has been reported (16). This possibility would seem impossible if the catheter were located much higher under the fascia iliaca.

The absence of obturator nerve blockade was even more marked when considered in terms of motor blockade alone, which is the only valid assessment of this nerve according to some clinicians (12,14,24). The hypothesis of differential blocking of this mixed nerve with a given concentration of local anesthetic-blocking sensory fibers while leaving motor fibers unaffected has been discussed (22,25). Exploring the sensory distribution of the obturator nerve is extremely difficult because it innervates a variable area of the medial aspect of the thigh or of the popliteal area. This distribution may be replaced by branches of the femoral nerve, sciatic nerve, or both, or it may not exist (11). In 76% of cases in a report by Bouaziz et al. (26), femoral block may have been confounded with obturator nerve block.

The VAS values in the patients of Group 1 were lower at 30 min than those of the two other groups. This information underlines the importance of combined analgesic blockade of the femoral nerve and the obturator nerve, which has branches innervating the hip and knee (23). A catheter situated in the lumbar plexus area may also contribute to anesthesia of the S1 root by paravertebral or epidural spread of the local anesthetic (6). Differences in the positioning of the catheters under the fascia iliac may, in part, account for certain inconsistencies in reports on the use of continuous three-in-one block for analgesia after major surgery of the lower limb (17,18).

However, the results of our study, which considered pain relief during the first hour after bolus injection of a local anesthetic, cannot be extrapolated to results concerning continuous infusion of an anesthetic from a subfascial iliaca catheter during 48 hours. The extent of anesthesia during a continuous facia iliaca compartment block varied with time. The femoral nerve block is well maintained because the catheter is near the femoral nerve, but the obturator and LFC blocks are more evanescent with time, particularly at 24–48 hours after surgery (10,27,28).

To summarize, our study demonstrates that the direction of a catheter threaded under the fascia iliaca is unpredictable. Such catheters tend not to course to over the lumbar plexus. Consequently, the designations continuous "lumbar plexus" or "three-in-one" blocks are misleading. The quality of sensory and motor blockades and of the initial postoperative analgesia depends on the placement of the catheter under the fascia iliaca. Comparison of different local anesthetics administered by three-in-one blocks catheters, of two anesthetic techniques of regional analgesia (continuous three-in-one and fascia iliaca compartment blocks, for example), or of two studies is possible only if the position of the catheter tip is verified to avoid methodological biases in the analysis of results.

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