

# Comparison of epidural, continuous femoral block and intraarticular analgesia after anterior cruciate ligament reconstruction

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**Background:** The purpose of this study was to compare three locoregional techniques of pain management after arthroscopic anterior cruciate ligament reconstruction (ACLR).

**Methods:** Sixty ASA I–II subjects were enrolled after obtaining written informed consent. Patients were randomly allocated to three groups of 20 subjects. The first group (EPI) received epidural ropivacaine 0.2% plus sufentanil  $0.2\mu\text{gml}^{-1}$ , at  $5\text{mlh}^{-1}$ . Patients in the second group (CFB) were given a continuous infusion of the same analgesic mixture through a femoral catheter. The third group (IA) received a continuous intraarticular infusion of ropivacaine 0.2% plus sufentanil  $0.2\mu\text{gml}^{-1}$ , at  $5\text{mlh}^{-1}$ . All subjects were allowed PCA boluses of 5 ml of local anesthetic. Analgesia was assessed for 36h after the end of surgery by means of a visual analog scale (VAS) and a verbal scale (VS), as well as the number of PCA boluses administered and the amount of supplementary i.v. ketorolac, if given.

**Results:** The VAS and VS scores were significantly higher in group IA during the 24h following surgery. Ketorolac requirement was higher in group IA throughout the postoperative ob-

servation. Adverse effects were similar in all groups except for urinary retention, which was significantly more frequent in group EPI.

**Conclusions:** We conclude that either epidural or continuous femoral nerve block provide adequate pain relief in patients who undergo ACLR, whereas intraarticular analgesia seems unable to cope satisfactorily with the analgesic requirements of this surgical procedure.

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**Key words:** analgesics, opioids: sufentanil; analgesics, local: ropivacaine; analgesia: postoperative, epidural, femoral nerve block, intraarticular, patient-controlled; pain: postoperative, patient-controlled analgesia; surgery: anterior cruciate ligament reconstruction.

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ANTERIOR cruciate ligament reconstruction (ACLR) is associated with moderate to severe postoperative pain (1,2). Locoregional analgesia techniques are endowed with faster patient recovery and less side-effects than intravenous administration of opioids (1,2). The combined use of local anesthetics and opioids provides better pain relief and fewer side-effects than any of these agents alone (3,4). Different locoregional techniques have been applied for ACLR. Effective postoperative analgesia has been achieved with epidural infusion of local anesthetics and/or opioids (1,5). Femoral nerve block after ACLR either as a single bolus dose (6,7) or as a continuous infusion (8,9) markedly decreased intravenous analgesic requirements. Intraarticular administration of bupivacaine and/or morphine provided satisfactory and long-lasting pain relief (3,4,10). To our knowledge, however, no study has compared all these techniques.

The aim of this study was therefore to compare the

analgesic and clinical effects of postoperative pain management with ropivacaine and sufentanil administered via an epidural, femoral or intraarticular catheter in patients undergoing ACLR, as well as the need for supplemental intravenous analgesic drugs and patient satisfaction with the three techniques.

## Methods

Sixty adults, ASA class I–II, were consecutively enrolled in this prospective, randomized study after written informed consent was obtained. The study was approved by the hospital Ethics Committee. All patients were scheduled for elective arthroscopically assisted ACLR with the middle third bone, patellar tendon, bone autograft technique. Exclusion criteria were: hypersensitivity or known allergy to local anesthetics, NSAIDs or opioids, the presence of any contraindication to locoregional anesthesia or the

need for any additional surgical procedure other than partial or total meniscectomy. Subjects were then assigned to three groups of 20 using a computer-generated list of random numbers.

Patients in the first group (EPI) received an epidural anesthesia after insertion of an epidural catheter through a 18-G Tuohy needle (Perifix, B.Braun, Germany) with a paramedian approach at L<sub>2</sub>-L<sub>4</sub> level. After a test dose of mepivacaine 1% 30mg (Carbocaine, Astra Laboratories, Sweden), a 7-ml bolus of an 11-ml mixture containing ropivacaine 1% (Naropine, Astra Laboratories), clonidine 75 µg (Catapresan, Boehringer Ingelheim, Spain) and sufentanil 15–20 µg (Fentatienil, Janssen Pharm., Belgium) was administered. This group received postoperative epidural analgesia with ropivacaine 0.2% plus sufentanil 0.2 µg ml<sup>-1</sup> using an infusion pump (Rythmic, Alaris Medical Systems, UK) at a rate of 5 ml h<sup>-1</sup>. Patients were allowed patient-controlled analgesia (PCA) boluses of 5 ml each with a lock out period of 2 h. The second group (CFB) received both a 3-in-1 lumbar plexus block, as described by Winnie *et al.* (11), with a catheter using the needle technique (Contiplex, B.Braun) and a single-shot sciatic nerve block using the Raj approach (12). Both blocks were performed using a nerve stimulator (Stimuplex, B.Braun) with a current intensity of 0.5 mA or less. On reaching appropriate muscle contraction, ropivacaine 0.75% 20 ml and clonidine 75 µg were injected for each block, up to a total of 40 ml of ropivacaine 0.75% and 150 µg of clonidine. A catheter was also placed inside the femoral sheath for postoperative analgesia. This group was given postoperative analgesia by means of a continuous femoral infusion of 5 ml h<sup>-1</sup> of the same analgesic mixture described for the first group, including PCA boluses. The third group (IA) received epidural anesthesia as described for group EPI. Before closure of the wound, a catheter for postoperative pain management was introduced intraarticularly through an 18-G needle. Postoperative analgesia consisted of the same infusion regimen as the other two groups. All postoperative pain management procedures were initiated at the end of surgery and continued for 36 h. The protocol also included intravenous ketorolac tromethamine (Toradol, Recordati Pharm., Italy) boluses of 30 mg each as rescue analgesia doses, meaning that a dose of ketorolac was administered i.v. when the patient was still complaining of pain 10–15 min after self-administration of a PCA bolus. All patients were discharged on the second postoperative day, after discontinuation of all regional analgesic treatments.

During the first 36 h following surgery, patients were monitored for pain intensity using a visual anal-

og scale (VAS; 0–100 mm), a five-point verbal rating scale (VS; 0 = no pain, 1 = mild pain, 2 = moderate pain, 3 = severe pain, 4 = very severe pain), the number of PCA boluses received by each group, and the intravenous ketorolac tromethamine requirement. Mean arterial pressure (MAP), heart rate (HR), respiratory rate (RR), motor block intensity by a modified Bromage scale (0 = full range of movements, 1 = moves feet and knees, 2 = moves feet only, and 3 = unable to move feet or knees) and the incidence of side-effects (nausea, vomitus, pruritus, hypotension, headache, sedation and urinary retention) were also recorded. Data was collected by an unbiased observer who was not otherwise involved in the study at the following times: as soon as the patient was dismissed from the PACU (t=0) and 6, 24 and 36 h after surgery. Patients were moreover asked to rate their satisfaction with the regimen of analgesia (1 = insufficient, 2 = sufficient, 3 = good, 4 = excellent).

### Statistical analysis

Data in the text and tables are expressed as mean ± SD or median (range) as appropriate. The primary outcome variable for the study was pain, assessed on a VAS. A power analysis of preliminary data indicated that a sample size of 17 was required to find a 50% difference in the VAS scores on the first postoperative day with a type I error of 5% and a power of 80%. The sample size of the study was then set at 20 for each group. Demographic data was evaluated by analysis of variance for numerical data and a  $\chi^2$  (chi-square) test for categorical data. For MAP, HR, and RR evaluation, analysis of variance for repeated measures and posthoc comparisons with the Bonferroni correction were used after testing homogeneity of variance. The VAS and VS scores were analyzed by the Kruskal–Wallis test. If a significant result was obtained, groups were then compared with the Mann–Whitney *U*-test. Bromage score and the frequency of side-effects were evaluated by means of  $\chi^2$ -analysis. Ketorolac doses, PCA boluses administered and degree of satisfaction were analyzed with the Mann–Whitney *U*-test. A value of  $P < 0.05$  was considered statistically significant.

## Results

Sixty patients were consecutively enrolled in the study, as none of those qualifying for inclusion refused randomization. All ACLR procedures were performed by the same surgeon. The three groups were homogeneous according to age (EPI: 33.3 ± 9.35, CFB: 29.7 ± 8.4, IA: 28.1 ± 8 years), sex (EPI: 17 males, three

Table 1

Clinical parameters and Bromage score during our observation period.

		T=0	6h	24h	36h
Mean arterial pressure (mmHg)	EPI	83 (77–92)	85 (75–87)	86 (81–93)	83 (83–91)
	CFB	92 (84–97)	87 (84–93)	91 (80–96)	86 (83–93)
	IA	86 (78–90)	85 (80–93)	89 (83–93)	86 (77–93)
Heart rate (b.p.m.)	EPI	71 (65–79)	70 (65–76)	71 (66–79)	70 (65–76)
	CFB	70 (64–74)	72 (70–75)	71 (69–79)	71 (70–78)
	IA	65 (61–71)	70 (69–74)	75 (70–80)	70 (64–80)
Respiratory rate (breaths $\text{min}^{-1}$ )	EPI	15 (13–16)	14 (14,15)	14 (13–15)	14 (13–16)
	CFB	14 (13–16)	14 (14,15)	14 (14–16)	14 (13–15)
	IA	14 (13–16)	14 (13–16)	14 (13–16)	14 (13–16)
Bromage scores	EPI	2 (2–2)	2 (1–2)	1 (0–2)	0 (0–1)
	CFB	2 (2–3)	2 (1–2)	1 (0–2)	0 (0–1)
	IA	2 (1–2)	1.5 (0–2)	0 (0–0)	0 (0–0)

Data are expressed as median and 25–75th percentiles.

EPI, epidural ropivacaine 0.2% and sufentanil 0.2 $\mu\text{gml}^{-1}$ ; CFB, continuous femoral block ropivacaine 0.2% and sufentanil 0.2 $\mu\text{gml}^{-1}$ ; IA, intraarticular ropivacaine 0.2% and sufentanil 0.2 $\mu\text{gml}^{-1}$ .

female, CFB: 16 male, four female, IA: 18 male, two female) and body weight (EPI: 75.1 $\pm$ 10.5, CFB: 69.3 $\pm$ 9.9, IA 76.6 $\pm$ 11.2 kg).

During our observation, no significant differences were observed in MAP, HR and RR (Table 1). The VAS pain scores were significantly higher in the IA group compared with the EPI group 24h postoperatively [EPI: 17.5 (80) vs. IA: 40 (90),  $P<0.05$ ] (Fig. 1). This difference persisted when comparing the CFB and IA scores, without however, reaching statistical significance. Verbal pain scores between the groups fol-

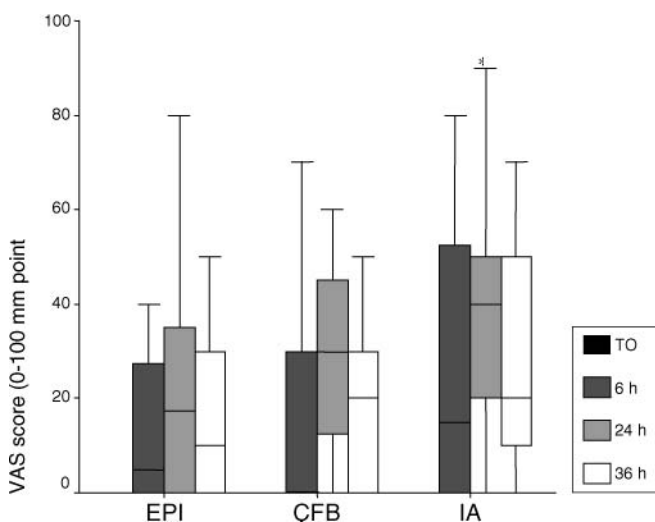


Fig. 1. Postoperative visual analog scale (VAS) pain scores at  $t=0$  (baseline) and at 6, 24 and 36h among the three groups. Each box represents the 25–75th interquartile range, medians are represented by the solid line. Error bars mark extreme values, excluding outliers. \* $P<0.01$  vs. EPI group. EPI, epidural; CFB, continuous femoral block; IA, intraarticular.

lowed the VAS and showed similar differences 24h after surgery ( $P<0.01$ ). Pearson's correlation test demonstrated a positive and highly significant correlation between the VAS and VS scores at all times ( $t=0$ :  $r=0.916$   $P<0.001$ , 6h:  $r=0.910$ ,  $P<0.001$  24h:  $r=0.843$ ,  $P<0.001$ , 36h:  $r=0.785$ ,  $P<0.001$ ). Analysis of the Bromage scale scores did not reveal significant differences between the three groups (Table 1).

The incidence of side-effects is illustrated in Table 2. Urinary retention was significantly more frequent in group EPI ( $P<0.001$ ) whereas the incidence of other side-effects was similar in all groups. The number of PCA boluses administered was similar in groups EPI and CFB while it was significantly higher in the IA group in comparison with the other two groups (Fig. 2). Differences in the i.v. rescue ketorolac requirement are shown in Fig. 3. Patients in group IA required 75 (150) mg compared with group EPI requiring 30 (90) mg ( $P<0.001$ ) and group CFB requiring 30 (120) mg ( $P<0.005$ ).

Patient satisfaction was greater in the EPI group than in the IA group (3.1 $\pm$ 0.64 vs. 2.3 $\pm$ 0.86, respectively,  $P<0.005$ ), while no significant difference was found between the other groups. Four patients in the IA group rated the analgesia technique as insufficient.

## Discussion

The main findings of our study are (i) differences in the pain scores between groups EPI and IA 24h after surgery, (ii) a lower intravenous ketorolac requirement for groups EPI and CFB, and (iii) the patients in group IA received more PCA boluses than those belonging to groups EPI and CFB.

Table 2

Adverse effects.							
	Nausea	Vomitus	Pruritus	Urinary retention	Sedation	Hypotension	Headache
EPI (n=20)	4	0	5	8	3	1	2
CFB (n=20)	10	1	1	0	4	0	0
IA (n=20)	6	1	5	0	2	0	0
P-value	0.122	0.596	0.168	<0.001*	0.676	0.362	0.126

Numbers in cells represent incidence of effect.

EPI, epidural ropivacaine 0.2% and sufentanil 0.2 µg ml<sup>-1</sup>; CFB, continuous femoral block ropivacaine 0.2% and sufentanil 0.2 µg ml<sup>-1</sup>; IA, intraarticular ropivacaine 0.2% and sufentanil 0.2 µg ml<sup>-1</sup>.

It is generally agreed that epidural analgesia provides adequate pain control after knee surgery and is at least as efficient as the i.v. administration of opioids (5,13). In this homogeneous study material we observed lower VAS scores with epidural infusion than with intraarticular administration of the same analgesic mixture after 24h. The failure to detect significant differences 6h after the beginning of the analgesic infusion might have resulted from a residual effect of the intraoperative epidural block on both groups (EPI and IA), while the lack of significance between the three groups after 36h could have been because of the administration of rescue analgesics as well as a physiological reduction of the nociceptive input.

Pain scores in the CFB group were low, suggesting that a continuous femoral block could be a valid alternative to epidural analgesia, particularly where an epidural block is contraindicated as, for example,

when the patient is being given anticoagulants. Accordingly, Lynch *et al.* (9) conclude that intermittent femoral nerve blockade after ACLR provides adequate analgesia, improves patient mobility and reduces the demand for systemic analgesics. Similar results were reported by Edkin *et al.* (7) in a study of 24 patients and by Tetzlaff *et al.* (8) who used low doses of bupivacaine via a femoral catheter. Other studies have investigated the use of a single-shot femoral nerve block as part of a multimodal analgesic approach (14,15). Mulroy *et al.* (14) concluded that femoral nerve block with 0.25% bupivacaine contributes significantly to multimodal analgesia in the immediate postoperative period. In contrast, other authors (15) have found that addition of a 3-in-1 blockade to intraarticular ropivacaine does not reduce the i.v. analgesic requirements following arthroscopic knee surgery. The latter study however, involved hamstring ACLR, which is associated with lower nocicep-

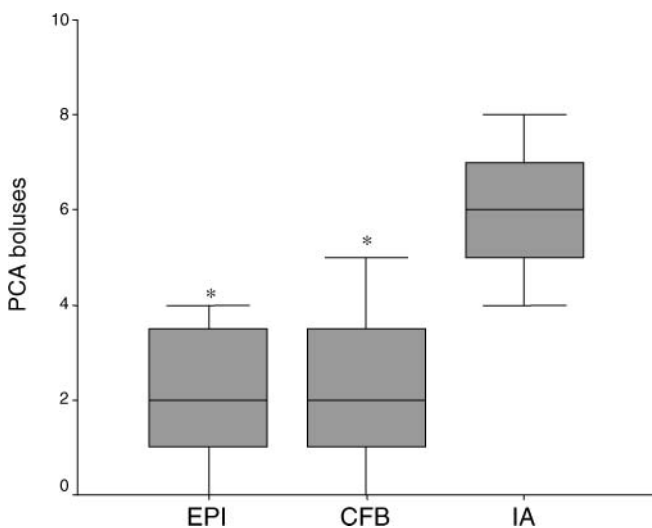


Fig. 2. Patient-controlled analgesia boluses among the three groups. The box represents the 25–75th percentiles, while the median is represented by the solid line. Error bars mark extreme values. \*  $P < 0.001$  vs. IA. EPI, epidural; CFB, continuous femoral block; IA, intraarticular.

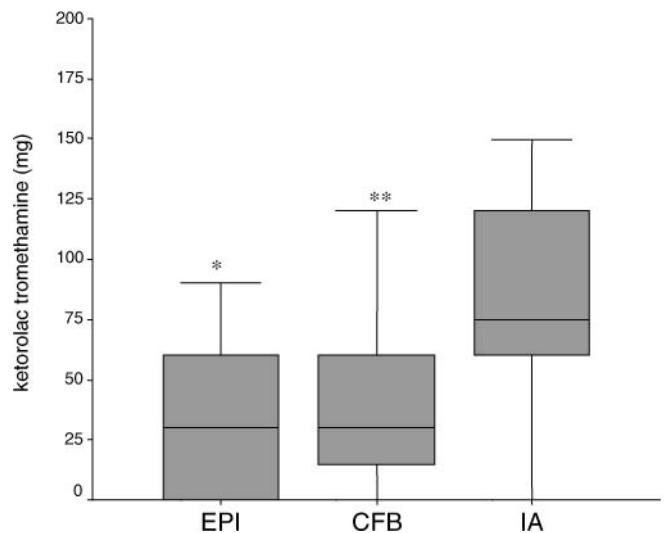


Fig. 3. Intravenous supplementary ketorolac requirement for the three groups. The box represents the 25–75th percentiles, while the median is represented by the solid line. Error bars mark extreme values. \*  $P < 0.001$  vs. IA, \*\*  $P < 0.005$  vs. IA. EPI, epidural; CFB, continuous femoral block; IA, intraarticular.

tive stimuli. The number of PCA boluses not differing significantly between groups EPI and CFB agrees with the similarly low pain scores. Detecting differences between these two groups would have required a significantly larger sample size and was beyond the purpose of this study. It is nonetheless worth remembering that as far as the initial anesthesia techniques are concerned sciatic and femoral nerve blocks require the use of greater amounts of local anesthetics than does epidural block.

Intraarticular analgesia is widely used in knee surgery and ACLR (3,4,10,16). Several studies have demonstrated that a combination of local anesthetics and opioids provides better pain relief than any of the above-used alone (10,16). Peripherally administered opioid agonists provide a significant level of analgesia after binding to peripheral receptors (17). Nevertheless, the higher pain scores, number of PCA boluses and intravenous analgesic requirements in the IA group suggest that this analgesia regimen might not be as efficient as the other two techniques for, in this case, pain originating from extraarticular sites, i.e. the graft donor site and surgical incisions does not seem to be adequately controlled. In this regard, in a recent study Butterfield *et al.* (18) report reduced i.v. analgesic consumption after pre- and postincisional bupivacaine wound infiltrations compared with intraarticular instillation of local anesthetics only at the end of surgery. The clear efficacy of intraarticular analgesia has been reported mainly after arthroscopy (16), whereas data concerning ACLR are far more controversial (3,4,10) and the use of intravenous opioids has been deemed almost mandatory. Finally, it is worth noticing that, although the use of sufentanil in intraarticular instillation has already been reported (19), this is the first study in which a combination of ropivacaine and sufentanil was used for intraarticular infusion.

An interesting feature of this study is represented by the use of a combined continuous plus PCA infusional device for intraarticular analgesia. Even though no data concerning the efficacy of their combined use for IA analgesia has yet been documented, we decided to use this technique for the third group as well, for it seemed the best way to allow all patients to receive the same exact amount of the drug in the same way, only in different anatomic locations. Our data leads us to conclude that, despite the fact that this combination surely enhances the possibilities of intraarticular analgesia it does not appear to be a satisfactory strategy for ACLR postoperative management.

Bromage scale scores were comparable in all groups

suggesting that low concentrations of ropivacaine do not determine motor block. As our sample consisted of in-patients that were all discharged on the 2nd day after surgery no investigations were performed for recovery time and total hospital stay.

There are several potential limitations in our study. Even though a prospective randomized double-blind controlled study is currently considered the golden standard in experimental design, it was not possible to perform our study in a blinded and controlled fashion because of the nature of the techniques and the need to preserve the patients' comfort. Pain scores were assessed only at rest, whereas when evaluating the efficacy of a certain analgesic modality in lower limb surgery, pain scores at rest and during movement are equally important. However our patients commenced physical rehabilitation by continuous passive movement on the 2nd postoperative day, after discontinuation of all regional analgesia techniques. Intraoperative anesthesia management was not equal among the three groups: group EPI and IA both received 75µg of clonidine and 15–20µg of sufentanil before surgery, while group CFB was given 150µg of clonidine and no opioid. Nonetheless systemic absorption of these drugs was very limited because no differences among the three groups of patients were apparent as far as sedation is concerned. It might also be argued that clonidine prolongs the analgesic effect of intraoperative treatment; however, this occurred in all groups, regardless of the type of postoperative pain management. Moreover, it is worth remembering that groups EPI and IA, which received half the dose of clonidine as group CFB, were given sufentanil, which might have dimmed considerably any dose-related difference in the analgesic effect among the three groups.

In conclusion, we found that both epidural analgesia and continuous femoral blockade provide effective analgesia with a low incidence of side-effects and a high patient satisfaction rate. Either technique may be chosen according to individual preference or possible contraindications. On the contrary, intraarticular analgesia was associated with significantly higher pain scores, higher additional analgesic requirements and a lower degree of patient satisfaction.

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