ORİJİNAL ARAŞTIRMA ORIGINAL RESEARCH

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# Analgesic Efficacy of Adductor Canal Block After Total Knee Arthroplasty

## Total Diz Artroplastisi Sonrası Adduktor Kanal Bloğunun Analjezik Etkisi

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*The study titled Analgesic Efficacy of Adductor Canal Block after Total Knee Arthroplasty of was planned and completed as a thesis of specialization in Anesthesiology and Reanimation.*



**ABSTRACT Objective:** Total knee arthroplasty (TKA) is a severely painful procedure even with the administration of extensive multimodal analgesics. We aim to assess whether US-guided adductor canal block (ACB) would improve postoperative pain scores and consequently decrease local anesthetic consumption by means of an epidural catheter with patient-controlled anaesthesia (PCA) device after TKA. **Material and Methods:** This was a retrospective study. Fifty-eight patients who underwent TKA between June 2015 and June 2016 and were fitted with either an epidural catheter with PCA (group A, n=30) or an epidural catheter with PCA followed by ACB (group B, n=28) were included in the study. PCA consumption during the postoperative 24 h and visual analogue scale (VAS) pain scores at 0, 4 and 24 h were determined. Motor block ending time and local anaesthetic drug consumption were also determined. **Results:** Basal bupivacaine and total bupivacaine consumption were reduced in group B 24 h postoperatively compared to that in group A. ACB reduced VAS score at 0 and 4 h post-operatively during movement. There was no statistically significant difference between VAS scores for each group at 24 h postoperatively. Motor block duration in group B patients who underwent ACB was longer than group A. **Conclusion:** Adductor canal block is effective for patients undergoing TKA. US-guided ACB reduced 24 h PCA requirements and VAS scores after TKA. ACB is a promising technique in producing effective and prolonged postoperative analgesia for patients undergoing TKA.

**Keywords:** Adductor canal block; epidural anaesthesia; ultrasound; total knee arthroplasty

**ÖZET Amaç:** Total diz artroplastisi (TDA) çoklu analjezik ilaç kullanımına rağmen oldukça ağrılı seyreden işlemdir. Biz ultrasonografi altında adduktor kanal bloğu (AKB) postoperatif ağrı skorunu düşürmeyi ve epidural kateter aracılığı ile hasta kontrollü ağrı (HKA) cihazında lokal analjezik ilaç kullanımını azaltmayı hedefledik. **Gereç ve Yöntemler:** Geriye dönük 2015-2016 haziran zaman aralığında kombine spinal epidural anestezi altında TDA geçiren hastalar, AKB yapılmayan 30 hasta (A grubu) ve yapılan 28 (B grubu) hasta şeklinde sınıflandırıldı. Hastaların HKA cihazı aracılığı ile ağrı kesici kullanımı ve postoperatif 0, 4 ve 24. saat ağrı skorları incelendi. Ayrıca motor blok sonlanma zamanı karşılaştırıldı. **Bulgular:** Bupivakainin bazal ve total tüketiminin A grubu ile karşılaştırıldığında B grubunda daha az olduğu saptanmıştır. AKB postoperatif 0 ve 4. saatlerdeki VAS skorunu azaltmıştır ancak her iki grup 24. saat VAS skorunda farklılık gözlenmemiştir. AKB uygulanan B grubunda motor blok süresi daha uzun bulunmuştur. **Sonuç:** AKB yapılan hastalarda postoperatif 0 ve 4. saatlerde bakılan VAS değeri daha düşük saptanmıştır. Postoperatif 24. saatte bakılan VAS değerleri kıyaslandığında gruplar arası anlamlı fark gözlenmemiştir. Adduktor kanal bloğu TDA geçiren hastalarda etkili bulunmuştur; postoperatif 24 saatlik süreçte HKA ilaç kullanımını ve VAS değerini düşürmüştür. AKB, TDA uygulanan hastalarda etkili ve uzun süreli postoperatif analjezi üretmede umut verici bir tekniktir.

**Anahtar Kelimeler:** Adduktor kanal bloğu; epidural anestezi; ultrasonografi; total diz artroplastisi

Total knee arthroplasty (TKA) is a severely painful procedure even with the administration of extensive multimodal analgesics. Effective postoperative analgesia, including peripheral nerve block, opioids and non-opioid medications, have been found to facilitate rehabilitation,

improve patient satisfaction and may reduce the length of hospital stay.[1]

In recent years, femoral nerve block (FNB) has been used as the primary method for controlling postoperative pain in knee surgeries. However, today's trend is to provide maximum analgesia while creating minimal motor block. In contrast to FNB, adductor canal block (ACB) causes only sensory nerve block, thus preserving quadriceps muscle strength and movement. Recent studies have shown that ACB preserves quadriceps strength to a greater extent than an FNB.[2-4] Previous studies have demonstrated that ACB reduces postoperative pain and morphine consumption compared to placebo administration without causing motor block.[5-7]

The use of ultrasound by anaesthesiologists performing regional blocks provides ease of intervention and reduces the duration of intervention. Ultrasound guidance shortens the block performance time, reduces the number of needle passes and shortens the block onset time.[8]

In the current clinical study, we aimed to assess whether US-guided ACB would improve postoperative pain scores and decrease local anaesthetic consumption by means of an epidural catheter with patient-controlled anaesthesia (PCA) device after TKA.

## MATERIAL AND METHODS

This retrospective randomised study was approved by Istanbul Health Sciences University, Kanuni Sultan Süleyman Training and Research Hospital Institutional Ethic Board at 17.06.2016, numbered 2016/19. Patients who underwent TKA between June 2015 and June 2016 were included in the study. We included 60 patients and 58 were studied (Figure 1). Two patients were excluded owing to inability to relay pain scores. The patients included were of the age range 35-80 years, had an ASA physical status I-III, body mass index of 18-45 kg/m$^2$ and had undergone TKA followed up by a 24-h PCA. Patients were excluded from study if they had alcoholism, known allergies to any drug used in the study, local infection at the block site or opioid abuse.

The files of patients who underwent TKA with combined spinal epidural anaesthesia (CSEA) were reviewed. From that list, we generated a comparative cohort of all patients who received either a single-shot ACB or did not receive ACB.

Patient charts were reviewed to determine demographic data such as patient age, sex, body mass index (BMI) and comorbidities. PCA forms were evaluated for the total consumption of local anaesthetics per patient for postoperative day 1. Records of the operative room were examined to determine operative time and if ACB was performed.

All patients who had undergone TKA under CSEA were divided into two groups; patients who did not receive ACB (group A, n=30) and those who received single-shot ACB with US-guidance (group B, n=28).

Standard monitoring of the patients was performed [electrocardiogram (ECG), non-invasive arterial blood pressure and pulse oximeter]. Intra-venous administration of 20G cannula was performed, and patients were prehydrated with 500 mL balanced electrolyte solution. Midazolam (0.05 mg/kg) was intravenously administered. The CSEA was performed using the loss-of-resistance technique in the sitting position. Ultrasound-guided (Esaote, MyLab Six) ACB was performed at the junction between the middle and distal third of the thigh after surgery with an 80 mm×22 gauge ultrasound-visible stimulation needle (B. Braun, Stimuplex® Ultra 360®). Isobaric bupivacaine (0.5%, 50 mg) was administered to the lateral femoral artery after negative aspiration.

An epidural PCA with 0.1% bupivacaine (basal infusion: 2 mL/h, bolus 2 mL every 30 min, maximum dose 6 mL/h) was prepared for the first 24 h postoperatively. Side effects and complications were recorded during the surgery and until 24 h postoperatively.

Ending times of motor and sensory block, mobilisation time and visual pain scores (VAS) were recorded at 0, 4 and 24 h postoperatively. The

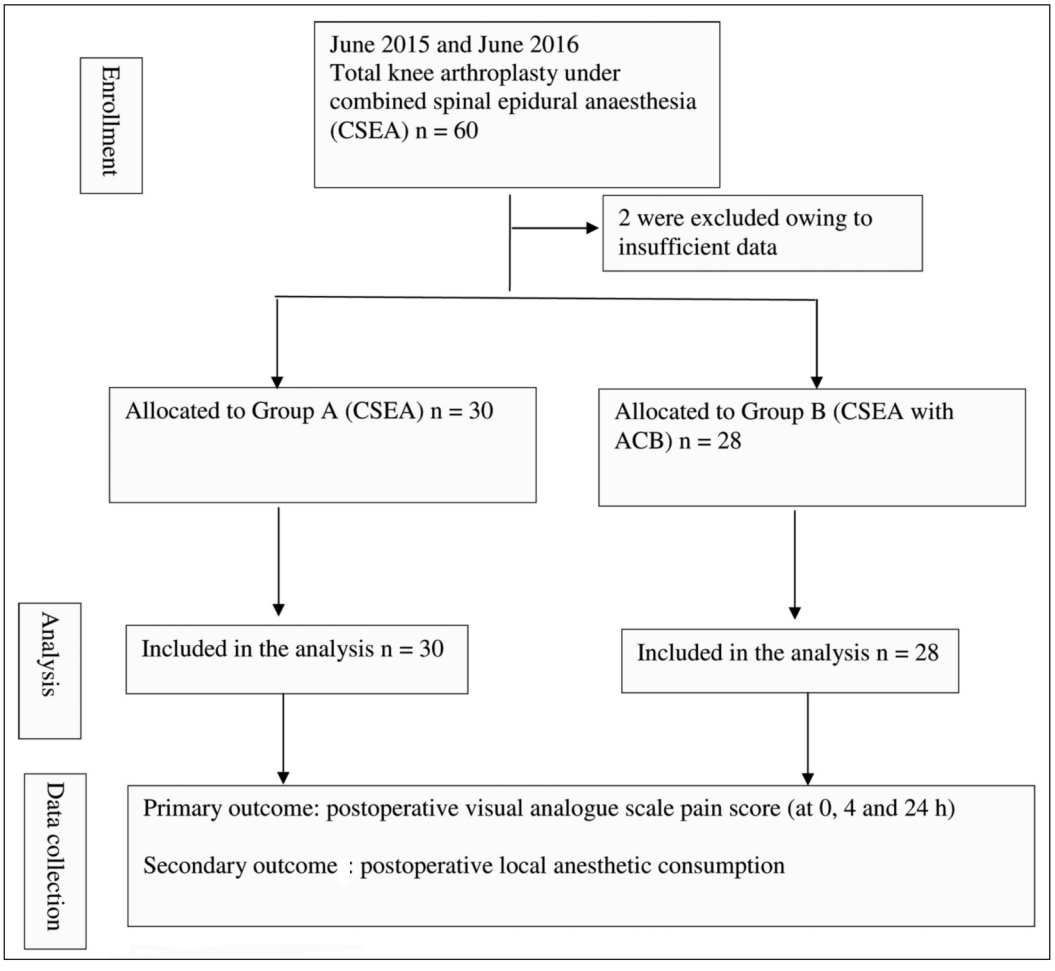


**FIGURE 1:** Patients undergoing total knee arthroplasty under CSEA only and under CSEA plus ACB.

total amount of analgesic and the demand dose from the PCA device were recorded at the end of 24 h. Also, at our orthopaedic clinic, surgeons routinely prescribe intravenous tenoxicam (20 mg, 1×1) and paracetamol (1000 mg, 2×1) after TKA.

### STATISTICAL ANALYSIS

SPSS for Windows 11.5 was used for statistical analysis. After evaluation of distribution using Shapiro-Wilk test, normally and non-normally distributed data were analysed with independent *t*-test and the Mann-Whitney *U*-test, respectively. Normally distributed data were detailed with the mean (plus SD) and non-normal data were detailed with the median (plus IQR). A $p$ value < 0.05 was considered statistically significant. Fisher's Chi-square test was used if the values in the table were <5; Pearson Chi-square test was used if they were >25 and Yates' Chi-square test was used for values between 5 and 25.

## RESULTS

Statistical analyses included 58 patients in total. The two groups were similar in age, weight, height and surgical duration (Table 1).

There were no statistically significant differences between groups in terms of mean arterial pressure and heart rate. Significant differences were found between the initial $SpO_2$ values in both groups ($p$=0.028, p<0.05) (Table 2).

Compared to group A at 24 h postoperatively, basal bupivacaine consumption and total bupivacaine consumption was less in group B ($p$<0.05) (Figure 1, Figure 2). Both groups showed a statistically significant difference in the mean

**TABLE 1:** Patient characteristics.

| | Group A (n=30) | Group B (n=28) | p* |
|---|---|---|---|
| Age (years) | 66.5 | 69.0 | 0.791 |
| Sex (F/M) | 24/6 | 20/8 | 0.649 |
| BMI (kg/m$^2$) | 32±5.97 | 32±6.01 | 0.901 |
| ASA II/III | 20/10 | 21/7 | 0.683 |
| Duration of operation | 75±26.480 | 91±21.06 | 0.611 |

Results are expressed as mean ± SD or as numbers of patients.
BMI: Body mass index, ASA: American Society of Anaesthesiology
*independent *t*-test

**TABLE 2:** Hemodynamic parameters.

| | Group A n=30 | Group B n=28 | p# |
|---|---|---|---|
| Mean arterial pressure (mmHg) | | | |
| Preoperatively | 114.3±13.567 | 115.964±14.182 | 0.544 |
| 30$^{th}$ minute of surgery | 96.800±13.670 | 98±10.883 | 0.602 |
| End of surgery | 102.200±17.330 | 99.142±15.157 | 0.446 |
| Heart rate (bpm) | | | |
| Preoperatively | 79.533±12.358 | 80.678±13.643 | 0.858 |
| 30$^{th}$ minute of surgery | 72.766±9.789 | 68.964±8.749 | 0.300 |
| End of surgery | 73.933± 8.448 | 73.285 ⑥ 11.011 | 0.613 |
| $SpO_2$% | | | |
| Preoperatively | 96.100±3.187 | 97.928±2.402 | 0.028 |
| 30$^{th}$ minute of surgery | 99.066±1.412 | 99.464±1.035 | 0.346 |
| End of surgery | 99.285±0.985 | 99.464±0.999 | 0.525 |

Results are expressed as the mean ± standard deviation.
#Independent *t*-test

number of demand doses in the first postoperative 24 h ($p$=0.001) (Table 3).

The mean VAS scores of group A was 37.3± 7.85 mm and that of group B was 22.6±12.54 mm 24 h postoperatively. There was no statistically significant difference between the groups at 24 h postoperatively during movement ($p$=0.245).

There was a statistically significant difference with respect to VAS scores between group A and B at 0 h postoperatively ($p$=0.001, p<0.05). At 4 h postoperatively, the mean VAS scores of group A was 63.3±12.4 mm and group B was 28.6±12.9 mm with a statistically significant difference ($p$=0.001, p<0.05). At 24 h postoperatively, the mean VAS scores of group A was 37.3±7.85 mm and group B was 33.6±12.54 mm. There was no statistically significant difference between groups ($p$=0.245, p>0.05).

Comparison of postoperative motor block duration times showed that there was a statistically significant difference between group A and B ($p$=0.002). The motor block duration was longer in group B patients who underwent ACB.

## DISCUSSION

This study demonstrated that ACB after TKA reduced total local anaesthetic consumption with PCA during the first 24 h postoperatively. Furthermore, ACB reduced pain scores at 0 and 4 h postoperatively.

TKA is a severely painful procedure. The incidence of cardiac, renal and other systemic diseases is high prior to surgery in such patients. Because reduction of pain is associated with postoperative mortality and morbidity, the efficacy of the analgesic method used is of great importance,

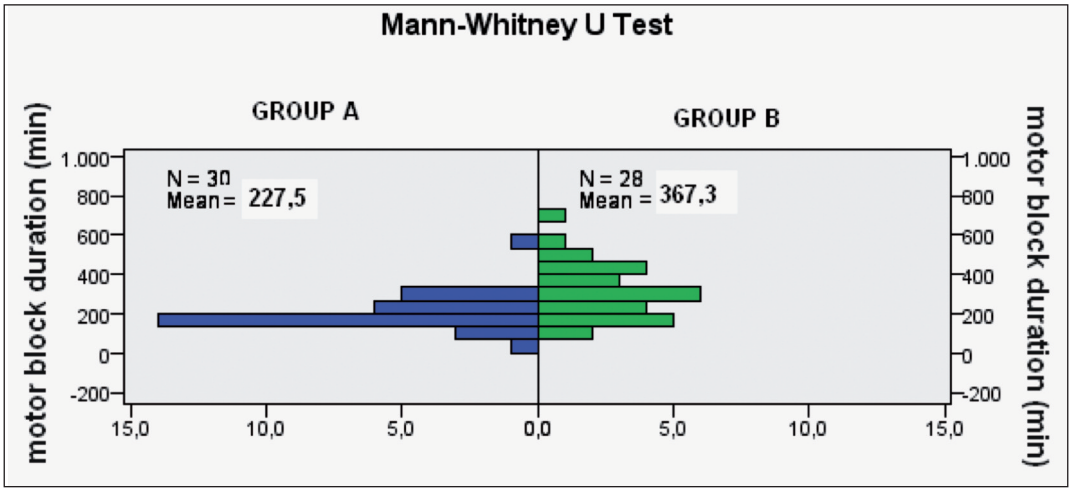


**FIGURE 2:** Motor block duration time.

**TABLE 3:** Patient-controlled analgesia device derived parameters.

| | Group A (n=30) | Group B (n=28) | p* |
|---|---|---|---|
| Total number of demand doses | 91 (47.5-238.750) | 18.5 (7.75-69) | 0.001 |
| Basal bupivacaine consumption at 24 h postoperatively (mL) | 18 (13.5-25.51) | 13.5 (7.75-18) | 0.013 |
| Total bupivacaine consumption at 24 h postoperatively (mL) | 85 (75.25-98.75) | 45 (42-53) | 0.001 |

Results tested using Mann-Whitney *U*-test are expressed as median ($25^{th}$-$75^{th}$ interquartile range).

with minimal opioid use and absence of motor block of the quadriceps muscle.[9] FNB is quite effective for postoperative analgesia; however, falling events occur frequently owing to quadriceps paralysis when continuous analgesia is performed with a perineural catheter.[10]

The adductor canal is a potential gap below the sartorius muscle. Proximal femoral triangle extends distally to the popliteal fossa.[11,12] Within the adductor canal, the saphenous nerve, which is a continuation of the femoral nerve, extends into the canal distal to the articular branch of the obturator nerve.[13]

Ishiguro et al. showed that a sensory block in the adductor canal using 0.75% bupivacaine results in minimal paralytic effect on the quadriceps muscle.[14] Although sensory nerves are commonly found in the adductor canal, injected local anaesthetics can partially affect the anterior and posterior branches of the femoral nerve. In a study by Krombach et al. the anterior and posterior branches of the femoral nerve were found to be involved after single dose of methylene-blue was injected in the adductor canal.[15] In this study, we found that motor block duration was longer in group B patients who underwent ACB.

Previous publications have reported that ACB is as effective as a FNB in patients undergoing TKA.[7,15,16] The results of these studies are consistent with our findings. In our study, ACB reduced the VAS scores at 0 and 4 h postoperatively during movement.

Jong Hae Kim and his colleagues conducted a study comprising 80 patients; the mean duration of surgery was 124.5 min in patients with CSEA and 135 min in patients with femoral and sciatic nerve block.[17] In our study, the mean duration of surgery of the patients in group A was 84±26.8 min and in group B was 79.5±21.0 min. In our institute, the orthopaedic surgical team believes that prolonged surgical time correlates with increased infection rate; hence, they tried to reduce the surgery time.

Initial $SpO_2$ values were statistically different between the two groups. In our opinion, the pre-existing systemic diseases of the patients caused this

oxygenation difference. No significant results were found in terms of hemodynamic findings.

In a meta-analysis by Gerrard et al. the postoperative VAS scores of the peripheral nerve block and epidural analgesia in patients with knee arthroplasty was compared and no significant difference was found. Peripheral nerve block methods, such as ACB and FNB, are as effective as epidural anaesthesia. In addition, epidural analgesia is more complicated than ACB and FNB because of its side effects such as nausea, vomiting and urinary retention.[18] In contrast to the findings of this study, we demonstrated that ACB had an additive post-analgesic effect to CSEA.

In a study by Jaeger et al. revision TKA group was compared with saline placebo group wherein both the groups received single-dose ACB. Resting VAS scores at 4 h postoperatively were 3.9±1.8 and 4.5±2.3, respectively.[5] In our study, VAS scores were found to be significantly lower at 0 and 4 h postoperatively in patients who underwent ACB, but there was no significant difference at 24 h postoperatively. We conclude from this finding that the combination of ACB and epidural analgesia is more effective on early postoperative pain.

Ozhan and colleagues compared the sensory and motor block durations of patients undergoing daily lower limb surgery who received peripheral nerve block (PNB) and spinal anaesthesia. The duration of block in PNB patients was found to be significantly longer. We also found that sensory and motor block times were significantly longer in patients with ACB.[19]

Lundblad and colleagues recorded an average duration of sensory block of 1626 min after saphenous nerve block, performed with 5 mL of 0.5% levobupivacaine in a study with ten adult volunteers with saphenous sinus in the subsartorial region. In our study, we found that the duration of sensory block was 206±107 min in group A and 337±159 min in group B. This effect may be owing to the differences in the half-life of local analgesic agents.[20]

Study of the 24-h PCA parameters of patients showed that the usage of analgesics in patients with ACB was significantly lower. Jiang et al. found similar results in their meta-analysis involving the evaluation of the efficacy of ACB.[21]

Despite the analgesic methods that we employed, the additional narcotic analgesics was required in 7/30 patients in group A and 5/28 patients in group B. In the meta-analysis by Jin et al., the saphenous nerve block group and the placebo group were examined and the saphenous nerve block group required less morphine.[22]

The results of our survey need to be carefully interpreted because of the following limitations. Our study was conducted at a single centre, which limits the capacity of our results to be generalised to other hospitals. Another limitation is associated with its retrospective design. In addition, the sample size presented here is fairly small and patients were not followed beyond hospital discharge for pain experience and medication use.

Clinical applications of regional anaesthesia techniques are increasing day by day. In patients with appropriate indications, general anaesthesia is quite overdue in terms of mortality, morbidity and cost compared to regional anaesthesia. PNBs using electrical stimulation and ultrasonography are preferable to central blocks. Particularly, the availability of ultrasonography in anaesthesiology clinics promotes the widespread use of PNBs in surgical anaesthesia and postoperative pain management.

The increase in ageing in the community increases the number of patients with gonarthrosis and associated total knee replacement surgeries. If there is no contraindication in these patients, PNB is an effective method for postoperative pain treatment. In our study, we observed that ACB significantly reduced the severity of the pain that patients experienced postoperatively. In addition, patients with ACB had less analgesic requirements and less total analgesic use with an epidural catheter PCA device.

In conclusion, the results of this trial indicate that ACB is effective for patients undergoing TKA. US-guided ACB reduced 24-h PCA requirements

and VAS scores after TKA. ACB is therefore a promising technique in providing effective and prolonged postoperative analgesia for patients undergoing TKA.


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*During this study, no financial or spiritual support was received neither from any pharmaceutical company that has a direct connection with the research subject, nor from a company that provides or produces medical instruments and materials which may negatively affect the evaluation process of this study.*


### *Conflict of Interest*

*No conflicts of interest between the authors and / or family members of the scientific and medical committee members or members of the potential conflicts of interest, counseling, expertise, working conditions, share holding and similar situations in any firm.*

### *Authorship Contributions*

***Idea/Concept:*** *Özal Adıyeke, M. Tayfun Aldemir, Yavuz Demiraran;* ***Design:*** *Özal Adıyeke, M. Tayfun Aldemir, Yavuz Demiraran;* ***Control/Supervision:*** *Özal Adıyeke, M. Tayfun Aldemir, Yavuz Demiraran;* ***Data Collection and/or Processing:*** *Özal Adıyeke;* ***Analysis and/or Interpretation:*** *Özal Adıyeke, M. Tayfun Aldemir, Yavuz Demiraran;* ***Literature Review:*** *Özal Adıyeke, M. Tayfun Aldemir, Yavuz Demiraran;* ***Writing the Article:*** *Özal Adıyeke, M. Tayfun Aldemir, Yavuz Demiraran;* ***Critical Review:*** *Özal Adıyeke, Yavuz Demiraran.*

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