Research Article

Early Postoperative Pain Control and Inflammation for Total Knee Arthroplasty: A Retrospective Comparison of Continuous Adductor Canal Block versus Single-Shot Adductor Canal Block Combined with Patient-Controlled Intravenous Analgesia

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Objective. The aim of this study was to compare pain control and inflammation among patients who received a continuous adductor canal block (CACB) versus single-shot adductor canal block (SACB) combined with patient-controlled intravenous analgesia (PCIA) for total knee arthroplasty (TKA) analgesia in the first two days after surgery. Design. Matched cohort retrospective study. Setting. University hospital. Patients. One hundred fifty-six patient charts were included in this study: 78 patients with CACB in Group A and 78 patients with SACB combined with PCIA in Group B. Patients were matched according to age, body mass index, and American Society of Anesthesiologists class. Measurements. The primary outcome of the study was Visual Analogue Scale (VAS) pain scores before operation (Pre) and at postoperative 6 (POH6), 12 (POH12), 24 (POH24), 30 (POH30), 36 (POH36), and 48 hours (POH48). Secondary outcomes included patient-controlled bolus, time of first postoperative ambulation, range of knee flexion and extension, inflammation cytokines on Pre and POH48, percentage of remedial analgesics treatment, incidence of adverse events and complications, hospital stay and cost, and Numerical Rating Scale (NRS) satisfaction scores at discharge. Main Results. Mean VAS scores at rest and with motion were lower in Group B than in Group A on all postoperative hours. At POH30, compared with Group A (1.1 ± 0.6), mean VAS scores at rest in Group B (0.9 ± 0.4) were lower (P < 0.048), and compared with Group A (2.6 ± 0.7), mean VAS scores with motion in Group B (2.2 ± 0.8) were lower (P = 0.001). The number of patient-controlled bolus was 4.3 ± 1.6 (95% CI 3.9–4.6) in Group A and 3.1 ± 1.3 (95% CI 2.8–3.4) in Group B, respectively (P < 0.001). Patients in Group B displayed better functional recovery and inflammation results at POH48 than Group A with respect to range of knee flexion and extension (117.8 ± 10.9° vs. 125.2 ± 9.4°, P < 0.001) and inflammation cytokines, including erythrocyte sedimentation rate (ESR), C-reactive protein (CRP), and interleukin-6 (IL-6) (43.8 ± 16.1) vs. (36.8 ± 13.2), P = 0.003; (34.9 ± 9.4 mg/L) vs. (29.6 ± 10.6 mg/L), P = 0.001; (21.3 ± 8.7 pg/ml) vs. (14.0 ± 7.0 pg/ml), P < 0.001). Conclusion. SACB combined with PCIA in the first two days of patients undergoing TKA has better analgesic and beneficial effects on functional recovery and inflammation.

1. Introduction

Total knee arthroplasty (TKA) is currently an advanced and effective method for the treatment of knee osteoarthritis. In the early stage after TKA, patients suffered from moderate to severe pain [1, 2] and obvious inflammation, which was manifested by the obvious increase in inflammatory cytokines such as interleukin-6 (IL-6), C-reactive protein (CRP), and erythrocyte sedimentation rate (ESR) [3, 4]. However, persistent postoperative pain and inflammation impair patients from achieving the desired knee joint function recovery after TKA [5].

Many modalities, such as adjuvant analgesic agents, patient-controlled intravenous analgesia (PCIA), epidural analgesia [6], periartricular infiltration, and peripheral nerve block [7–10], are used for pain relief after TKA. There is a
2. Materials and Methods

Institutional review board approval was obtained for this research. As this trial was retrospective in nature, neither written informed consent nor clinical trial registration were required.

A total of 300 patient charts were screened for review from February 2019 to May 2021, and we retrospectively analyzed the anesthesia record list, hospital chart, and the iPainfree system, which was the pain management information system used for recording the patient-controlled analgesia (PCA) follow-up data. Patients who met the following criteria were excluded: (1) long-term abuse of opioids; (2) preexisting neuropathy in the ipsilateral lower extremity; (3) incomplete documentation for any of the primary or secondary outcome variables; (4) received bilateral TKA and/or other procedures; (5) transferred to the rehabilitation department to continue rehabilitation treatment without discharge; (6) accompanied by coagulation abnormalities or severe central nervous system diseases. Qualifying patients were matched according to age (18–90 years old), body mass index (BMI) (18–35 kg/m²), and American Society of Anesthesiologists (ASA) class (grade II–III). After this screening process, we recruited 156 patients who underwent a primary, selective, and unilateral TKA for knee osteoarthritis with general anesthesia by five orthopedic surgeons and two anesthesiologists in this study. 78 patients had CABC in Group A, and 78 patients had SACB combined with PCIA in Group B.

2.1. Outcome Measures. The following demographic and perioperative data were collected: gender, age, height, weight, BMI, ASA class, medical history, operation procedure, operation time, anesthesia method and content, intraoperative medication, anesthesia time, postoperative analgesia protocol, time of extubation, and length of stay in the postanesthesia care unit (PACU).

The primary outcomes of the study were Visual Analogue Scale (VAS) pain scores before operation (Pre) and at postoperative 6 hours (POH6), 12 hours (POH12), 24 hours (POH24), 30 hours (POH30), 36 hours (POH36), and 48 hours (POH48) rest and motion. Nerve block catheters and PCIA were discontinued at POH48.

Secondary outcomes were time of first postoperative ambulation; range of knee flexion and extension; inflammation cytokines (Pre and POH48), including erythrocyte sedimentation rate (ESR), C-reactive protein (CRP), and interleukin-6 (IL-6); incidence of adverse events (including patient-controlled bolus, dizziness, nausea and vomiting, and remedial analgesics treatment) and complications (including pulmonary infection, cardiovascular events, deep vein thrombosis, incisional infection, and unplanned second surgery); postoperative hospital stay, total hospital stay, total hospital cost, and patient self-reported satisfaction score at discharge. Numerical Rating Scale (NRS) was scored with range 0–10, 0 = not at all satisfied and 10 = very satisfied.

2.2. Intraoperative Course. Patients took celecoxib 200 mg orally daily for advanced analgesia and, if there were no contraindications, had low-molecular-weight heparin anti-coagulation after admission. Before surgery, patients abstained from food for 8 h and drinking for 2 h but drank the nutrition solution prepared by the nutrition department on the day of surgery.

Patients were routinely monitored for electrocardiogram, blood pressure, pulse oxygen saturation, respiratory rate, and temperature during the perioperative period. After general anesthesia induction, endotracheal intubation and mechanical ventilation were performed. Anesthesia was maintained with sevoflurane inhalation and intravenous infusion of propofol and remifentanil, and vecuronium was added intermittently as needed. Intravenous injection of dexamethasone (10 mg) and tropisetron (2 mg) was performed to prevent postoperative nausea and vomiting. Five different surgeons performed the procedures, and then, two different senior anesthetists performed adductor canal block on all patients immediately with the technique described by Jenstrup et al. [18]. After that, patients were transferred to PACU, the tracheal tube was removed when they reached the extubation indications, and then they were transferred to the ward.

Postoperative management measures included using parecoxib 40 mg daily for analgesia. Omeprazole for acid inhibition and gastric protection was used without contraindications. Low-molecular-weight heparin was used for preventing deep vein thrombosis. Cefuroxime was used for preventing infection and monitoring inflammation cytokines. Patients were encouraged to gradually resume their
diet and lower limb activities 2 hours after surgery. Rehabilitation physicians guided rehabilitation training at POH6 and encouraged patients to get out of bed as soon as possible.

2.3. Postoperative Analgesia Course

2.3.1. Group A. At the end of the operation, an adductor canal block was performed via guidance of ultrasound, injecting 20 ml 0.2% ropivacaine, and inserting a catheter, which was then properly fixed and connected to the electronic patient-controlled analgesic pump. Analgesic pump drugs in the CACB group were prepared with 300 ml of 0.17% ropivacaine. Analgesic pump parameters included load dose 5 ml; basal infusion rate 5 ml/h; patient-controlled bolus dose 5 ml; and security lock duration 45 minutes.

2.3.2. Group B. Single-shot adductor canal block was performed under ultrasound guidance after surgery, injected with 20 ml 0.2% ropivacaine without catheterization, and then intravenous infusion of the PCIA was started. Analgesic pump drugs in PCIA were prepared with tramadol 800 mg combined with flurbiprofen axetil 100 mg and saline mixed into 80 ml. Analgesic pump parameters included load dose 5 ml; basal infusion rate 1 ml/h; patient-controlled bolus dose 2 ml; security lock duration 15 minutes.

Based on a load dose, the PCA pump started to work continuously at the end of the operation. The department of anesthesiology had special personnel for following up the patients who use PCA at 6 h, 12 h, 24 h, 30 h, 36 h, and 48 h after surgery. They completed the follow-up records through the iPainfree pain management information system. They collected and recorded the hemodynamic parameters, patient self-reported pain scores (Visual Analogue Scale, VAS), and the adverse events including time of patient-controlled bolus, dosage of PCA, remedial analgesics treatment, dizziness, nausea and vomiting, sedation score, pruritus, urinary retention, sensory disorder, dyskinesia, and local puncture anomaly. The specific method of VAS score is as follows: a 10 cm line segment was drawn on a paper. The left end of the line segment is 0 points, indicating no pain, and the right end is 10 points, indicating severe pain (the pain degree increases gradually from left to right). Patients in the calm state was marked according to the self-marking line segment, indicating the degree of pain. If VAS scores ≥ 4, patients in both groups were treated with remedial analgesia: paracetamol and tramadol and/or celecoxib and/or gabapentin.

2.4. Statistics. Statistical analysis was conducted using SPSS 26.0 (International Business Machines Corporation, USA) software. Conformity of the data to normal distribution was tested with the Kolmogorov–Smirnov test. Data are shown as mean ± standard deviation, or number (percentage). To determine statistical significance, the ANOVA test was used for testing VAS pain score, ESR, CRP, IL-6, patient-controlled bolus, the range of knee flexion and extension, postoperative hospital stay, and NRS satisfaction score. Pearson’s chi square test was used for gender, ASA class, surgery side, and the incidence of adverse events and complications. *P* < 0.05 was considered as statistically significant.

3. Results

Between the CACB and SACB combined with the PCIA group, there was no significant difference in the demographic and perioperative data (Table 1; *P* > 0.05). As expected with our matching process, the percentage of the surgeons who performed surgery and the anesthetists who performed adductor canal block were no different. No neuropathic complications occurred in either group.

3.1. Pain Control. As shown in Figures 1 and 2, mean VAS scores at rest (1.1 ± 0.7 Group A vs. 1.0 ± 0.5 Group B, *P* = 0.288) and with motion (2.8 ± 0.8 Group A vs. 2.6 ± 0.8 Group B, *P* = 0.273) before operation were comparable. However, compared with Group A, the mean VAS scores at rest and with motion were lower in Group B at all postoperative hours. Compared with Group A, the mean VAS scores at rest (1.1 ± 0.6 vs. 0.9 ± 0.4, *P* = 0.048) and with motion (2.6 ± 0.7 vs. 2.2 ± 0.8, *P* = 0.001) in Group B were lower at POH30. The mean VAS scores at rest and with motion at POH6 and POH12 were lower than those before operation in both the groups (*P* < 0.012). The mean VAS scores at rest and with motion at POH12, POH24, POH30, POH36, and POH48 were higher than those at POH6 in both the groups (*P* < 0.015). The mean VAS scores at rest and with motion at POH24 and POH30 were higher than those at POH12 in both the groups (*P* < 0.04). The mean VAS scores with motion at POH36 were lower than those at POH30 in both the groups (*P* < 0.013).

The number of patient-controlled boluses was 4.3 ± 1.6 (95% CI 3.9–4.6) in Group A vs. 3.1 ± 1.3 (95% CI 2.8–3.4) in Group B, respectively (*P* < 0.01). There was no statistical difference between 9 patients (11.5%) in Group A and 5 patients (6.4%) in Group B using remedial analgesia (*P* = 0.402).

3.2. Functional Recovery. As shown in Figure 3, the range of knee flexion and extension before operation (99.9 ± 12.4° in Group A vs. 101.8 ± 10.9° in Group B, *P* = 0.323) was comparable. Compared with Group A, the range of knee flexion and extension at POH48 in Group B was higher, and the difference was statistically significant (117.8 ± 10.9° vs. 125.2 ± 9.4°, *P* < 0.001). Time of postoperative first ambulation was not statistically different (20.8 ± 4.1 h in Group A vs. 20.3 ± 3.9 h in Group B, *P* = 0.448).

3.3. Inflammation Cytokines. As shown in Figures 4–6, mean ESR, CRP, and IL-6 were lower before operation as compared to POH48 (*P* < 0.001). Compared with Group A, mean ESR, CRP, and IL-6 in Group B at POH48 were lower and the difference were statistically significant (43.8 ± 16.1 vs. 36.8 ± 13.2, *P* = 0.003; 34.9 ± 9.4 mg/L vs. 29.6 ± 10.6 mg/L, *P* = 0.001; 21.3 ± 8.7 pg/ml vs. 14.0 ± 7.0 pg/ml, *P* < 0.001)).
3.4. Economic Benefit. As shown in Tables 2 and 3, there was no significant difference in total hospital stay, incidence of dizziness, nausea and vomiting, pulmonary infection, and deep vein thrombosis between the two groups. Postoperative hospital stay was different between the two groups (\( \text{P} < 0.001 \)), estimated about 1.1 day less following the use of SACB combined with PCIA. Estimated hospital cost was different between the two groups (\( \text{P} < 0.001 \)), estimated about 4032 RMB less following the use of SACB combined with PCIA. Compared with Group A, NRS satisfaction scores in Group B were higher at discharge and the difference was statistically significant (9.5 ± 0.3 vs. 9.7 ± 0.2, \( \text{P} < 0.001 \)). Complications of cardiovascular events, incisional infection, and unplanned second surgery did not occur in either group.

4. Discussion

In this study, we found that the combination of SACB and PCIA was more effective than CACB alone in the management of early postoperative pain after TKA. VAS scores at rest in almost all postoperative hours and VAS scores with motion at all postoperative hours in both the groups were significantly lower than preoperation VAS scores, which indicated that both CACB and SACB combined with PCIA could effectively control the postoperative pain after TKA. Remarkably, the CACB group seemed to be the least beneficial modality of the two, which had the higher rest and motion VAS scores in all postoperative hours and needed more supplemental patient-controlled bolus and remedial
analgesics treatment. There was a strong trend toward superiority of the SACB combined with PCIA group over CACB at POH30. The time of first postoperative ambulation was 15–30 hours after surgery in 90% patients in both the groups, and the VAS scores were significantly higher at POH24 and POH30 compared with POH6. It was not hard to see that the trend of VAS scores was likely related to postoperative rehabilitation training and movement [19, 20] in both groups. Like any continuous blockade technique, we ascribed CACB fared so poorly in this trial to secondary block failure [21, 22] or catheter displacement [23].

Severe pain was present after TKA [1, 2, 19] and lasted for 2-3 days after surgery [24]. A multimodal pain management protocol [9, 12, 13, 25, 26] after TKA has been shown to decrease narcotic usage [21], improve pain score/satisfaction, and facilitate joint early function rehabilitation.
over traditional patient-controlled intravenous analgesia (PCIA) alone [12, 27]. Canbek et al. showed that pain control following TKA was found to be superior in the patients given CACB compared with SACB, with better ambulation and functional recovery, and that SACB alone was not recommended to be used as an analgesia method [14]. According to the previous studies, the ERAS team in our orthopedics department implemented CACB or SACB combined with PCIA for TKA postoperative analgesia. To our knowledge, this was the first study to investigate pain control in patients received SACB when used in combination with PCIA in the first two days after TKA. All the adductor canal blocks in this study were performed by two experienced anesthetists with ultrasound visualization of both the catheter tip and local anesthetic spread during the initial bolus. In addition, multimodal analgesic treatment for all patients in our study started from admission, and systematic pain management was carried out throughout the perioperative period.

As we all know, the concentration and dose of local anesthetics have a great influence on the effect and duration of nerve block and that increasing the concentration and

Table 2: Secondary outcomes.

| Characteristic                        | Group A (n = 78) | Group B (n = 78) | P value |
|---------------------------------------|------------------|------------------|---------|
| Postoperative first ambulation time (h) | 20.8 ± 4.1       | 20.3 ± 3.9       | 0.448   |
| Patient-controlled bolus (times)      | 4.3 ± 1.6        | 3.1 ± 1.3        | ≤0.001* |
| Postoperative hospital stay (d)       | 5.8 ± 1.6        | 4.7 ± 1.5        | ≤0.001* |
| Total hospital stay (d)               | 10.4 ± 2.6       | 9.6 ± 2.8        | 0.058   |
| Total hospital cost (RMB)             | 60496.1 ± 8481.4 | 56464.9 ± 6045.7 | 0.001†  |
| NRS satisfaction scores at discharge  | 9.46 ± 0.27      | 9.66 ± 0.17      | ≤0.001* |

Note. Values are presented as mean ± SD. PCA = patient-controlled analgesia; NRS = Numerical Rating Scale.* P < 0.001; † P < 0.05.

Table 3: Incidence of adverse events and complications.

| Characteristic                        | Group A (n = 78) | Group B (n = 78) | P value |
|---------------------------------------|------------------|------------------|---------|
| Remedial analgesics treatment (n, %)  | 9 (11.5%)        | 5 (6.4%)         | 0.402   |
| Dizziness, nausea and vomit (n, %)   | 4 (5.1%)         | 5 (6.4%)         | 1       |
| Pulmonary infection (n, %)            | 2 (2.6%)         | 0                | 0.497   |
| Cardiovascular events (n, %)          | 0                | 0                | 1       |
| Deep vein thrombosis (n, %)           | 2 (2.6%)         | 1 (1.3%)         | 1       |
| Incisional infection (n, %)           | 0                | 0                | 1       |
| Unplanned second surgery (n, %)       | 0                | 0                | 1       |

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dose of local anesthetics carries the risk of causing systemic toxicity. The concentration of ropivacaine used for adductor canal block has been reported to vary widely from 0.1% to 0.75% [20, 28, 29], and the dosage of ropivacaine also varies widely from 5 ml to 40 ml [10, 15, 30, 31]. Wang et al. had found that EV50 of 0.5% ropivacaine for ACB was 10.79 ml (95% CI 10.10–11.52 ml) [32]. Christiansen et al. had found that no effect of increasing the volume of ropivacaine 0.2%
had the advantage of high security for postoperative analgesia after TKA [37]. We therefore performed CACB with 0.2% ropivacaine 5 ml/h could effectively be used for analgesia after TKA [37]. Therefore, we performed CACB with 0.2% ropivacaine bolus followed by infusion of 0.17% ropivacaine 5 ml/h, which had lower concentration and volume than previous studies [34–36], and had the advantage of high security for postoperative analgesia, and the patients can get out of bed as early as possible.

Surgery and anesthesia could lead to a strong stress response and a significant increase of inflammatory cytokines in patients, which are related to postoperative pain, anxiety, fear, and so on. ESR was a nonspecific inflammatory index, while CRP was a sensitive index for monitoring tissue damage and inflammatory response in clinical practice at present, which was also an important evaluation index in the process of postoperative recovery [38]. IL-6 was a major proinflammatory factor, and its expression level was closely related to the degree of tissue injury caused by surgery [39]. The adjuvant analgesic agents, including celecoxib, parecoxib, and flurbiprofen axetil, which were all some of the nonsteroidal anti-inflammatory drugs (NSAIDs), were a part of multimodal analgesic treatment for all patients in our study carried out throughout the perioperative period. Klifto et al. had reported that NSAIDs (parecoxib and celecoxib) have been shown to decrease inflammation, pain, and fever [40]. Hu et al. had found that flurbiprofen 100 mg could effectively suppress the elevation of serum interleukin-6 concentration after radical excision of breast cancer [41]. Yang et al. had also reported that adductor canal block combined with cyclooxygenase 2 (COX-2) selective inhibitors (parecoxib and celecoxib) could inhibit the inflammatory response after TKA [42]. As shown in our research, the inflammatory cytokines (ESR, CRP, and IL-6) at POH48 in the SACB combined with the PCIA group were lower, which is probably related to the use of celecoxib, parecoxib, and flurbiprofen axetil in PCIA.

In conclusion, ultrasound-guided single-shot adductor canal block combined with patient-controlled intravenous analgesia appeared to provide better analgesia when compared to continuous adductor canal block in the first two days after total knee arthroplasty. It was beneficial for patients in a globally economical manner, inhibited inflammation, and did not increase the incidence of adverse events and complications and thus achieved the purpose of enhanced recovery after surgery.

5. Conclusion

In conclusion, ultrasound-guided single-shot adductor canal block combined with patient-controlled intravenous analgesia appeared to provide better analgesia when compared to continuous adductor canal block in the first two days after total knee arthroplasty. It was beneficial for patients in a globally economical manner, inhibited inflammation, and did not increase the incidence of adverse events and complications and thus achieved the purpose of enhanced recovery after surgery.

Data Availability

The data used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Ethical Approval

This study was approved by the Ethics committee of The First Affiliated Hospital of Chongqing Medical University (2019004).

Conflicts of Interest

The authors declare there are no conflicts of interest.

References

[1] I. Grosu, P. Lavand’homme, and E. Thienpont, “Pain after knee arthroplasty: an unresolved issue,” Knee Surgery, Sports Traumatology, Arthroscopy, vol. 22, no. 8, pp. 1744–1758, 2014.

[2] S. S. Liu, A. Buvanendran, J. P. Rathmell et al., “Predictors for moderate to severe acute postoperative pain after total hip and knee replacement,” International Orthopaedics, vol. 36, no. 11, pp. 2261–2267, 2012.
[3] S. Honsawek, B. Deepaisarnsakul, A. Tanavalee et al., “Relationship of serum IL-6, C-reactive protein, erythrocyte sedimentation rate, and knee skin temperature after total knee arthroplasty: a prospective study,” *International Orthopaedics*, vol. 35, no. 1, pp. 31–35, 2011.

[4] S. Shah, C. Brown, J. Owen, B. Fisher, R. Natarajan, and S. Kate, “Vitamin C and inflammatory cytokine levels in elective total knee arthroplasty,” *Nutrition and Health*, vol. 26, no. 2, pp. 87–91, 2020.

[5] M. C. Dixon, R. R. Brown, D. Parsch, and R. D. Scott, “Modular fixed-bearing total knee arthroplasty with retention of the posterior cruciate ligament: A study of patients followed for a minimum of fifteen years,” *The Journal of Bone and Joint Surgery*, vol. 87, no. 3, pp. 598–603, 2005.

[6] A. Willett, R. Lew, and R. Wardhan, “Is continuous proximal adductor canal analgesia with a periarticular injection comparable to continuous epidural analgesia for postoperative pain after total knee arthroplasty? A retrospective study,” *Romanian Journal of Anaesthesia And Intensive Care*, vol. 26, no. 1, pp. 9–15, 2019.

[7] A. S. Terkawi, D. Mavridis, D. I. Sessler et al., “Pain management modalities after total knee arthroplasty,” *Anesthesiology*, vol. 126, no. 5, pp. 923–937, 2017.

[8] T. F. Bendtsen, B. Moriggl, V. Chan, and J. Borglum, “The optimal anaesthetic block for total knee arthroplasty,” *Regional Anesthesia and Pain Medicine*, vol. 41, no. 6, pp. 711–719, 2016.

[9] C. A. Webb and E. R. Mariano, “Best multimodal analgesic protocol for total knee arthroplasty,” *Pain Management*, vol. 5, no. 3, pp. 185–196, 2015.

[10] I. J. Koh, Y. J. Choi, M. S. Kim, H. J. Koh, M. S. Kang, and Y. In, “Femoral nerve block versus adductor canal block for analgesia after total knee arthroplasty,” *Knee Surgery and Related Research*, vol. 29, no. 2, pp. 87–95, 2017.

[11] J. C. Gadsden, S. Sata, W. M. Bullock, A. H. Kumar, S. A. Grant, and J. R. Dooley, “The relative analgesic value of a femoral nerve block versus adductor canal block following total knee arthroplasty: a randomized, controlled, double-blinded study,” *Korean Journal Of Anesthesiology*, vol. 73, no. 5, pp. 417–424, 2020.

[12] J. D. Lamplot, E. R. Wagner, and D. W. Manning, “Multimodal pain management in total knee arthroplasty,” *The Journal of Arthroplasty*, vol. 29, no. 2, pp. 329–334, 2014.

[13] X. Q. Zhao, N. Jiang, F. F. Yuan, L. Wang, and B. Yu, “The comparison of adductor canal block with femoral nerve block following total knee arthroplasty: a systematic review with meta-analysis,” *Journal of Anesthesia*, vol. 30, no. 5, pp. 745–754, 2016.

[14] U. Canbek, U. Akgun, N. H. Aydogan, C. Y. Kihinc, and A. I. Uysal, “Continuous adductor canal block following total knee arthroplasty provides a better analgesia compared to single-shot: a prospective randomized controlled trial,” *Acta Orthopaedica et Traumatologica Turcica*, vol. 53, no. 5, pp. 334–339, 2019.

[15] N. A. Shah, N. P. Jain, and K. A. Panchal, “Adductor canal blockade following total knee arthroplasty-continuous or single-shot technique? Role in postoperative analgesia, ambulation ability and early functional recovery: a randomized controlled trial,” *The Journal of Arthroplasty*, vol. 30, no. 8, pp. 1476–1481, 2015.

[16] R. Tak, A. V. Gurava Reddy, K. Jhakotia, K. Karumuri, and S. R. Sankineani, “Continuous adductor canal block is superior to adductor canal block alone or adductor canal block combined with IPACK block (interspace between the popliteal artery and the posterior capsule of knee) in postoperative analgesia and ambulation following total knee arthroplasty: randomized control trial,” *Musculoskeletal Surgery*, vol. 1, p. 27, 2020.

[17] Q. Zhuang, L. Tao, J. Lin et al., “Postoperative intravenous paracetamol sodium followed by oral celecoxib post total knee arthroplasty in osteoarthritis patients (PIPPFORCE): a multicentre, double-blind, randomised, placebo-controlled trial,” *BJM Open*, vol. 10, no. 1, Article ID e003051, 2020.

[18] M. T. Jenstrup, P. Jaeger, J. Lund et al., “Effects of adductor canal-blockade on pain and ambulation after total knee arthroplasty: a randomized study,” *Acta Anaesthesiologica Scandinavica*, vol. 56, no. 3, pp. 357–364, 2012.

[19] U. Grevstad, O. Mathiesen, T. Lind, and J. B. Dahl, “Effect of adductor canal block on pain in patients with severe pain after total knee arthroplasty: a randomized study with individual patient analysis,” *British Journal of Anaesthesia*, vol. 112, no. 5, pp. 912–919, 2014.

[20] Y. Zhang, Z. Tan, R. Liao et al., “The prolonged analgesic efficacy of an ultrasound-guided single-shot adductor canal block in patients undergoing total knee arthroplasty,” *Orthopedics*, vol. 41, no. 5, pp. e670–e674, 2018.

[21] N. A. Hanson, C. J. Allen, L. S. Hostetter et al., “Continuous ultrasound-guided adductor canal block for total knee arthroplasty: a randomized, double-blind trial,” *Anesthesia and Analgesia*, vol. 118, no. 6, pp. 1370–1377, 2014.

[22] S. Lee, N. Rooban, H. Vaghadia, A. N. Sawka, and R. Tang, “A randomized non-inferiority trial of adductor canal block for analgesia after total knee arthroplasty: single injection versus catheter technique,” *The Journal of Arthroplasty*, vol. 33, no. 4, pp. 1045–1051, 2018.

[23] D. Marhofer, P. Marhofer, L. Triffner, M. Leonhardt, M. Weber, and M. Zeitlinger, “Dislocation rates of perineural catheters: a volunteer study,” *British Journal of Anaesthesia*, vol. 111, no. 5, pp. 800–806, 2013.

[24] R. K. Elmallah, J. J. Cherian, T. P. Pierce, J. J. Jauregui, S. F. Harwin, and M. A. Mont, “New and common perioperative pain management techniques in total knee arthroplasty,” *Journal of Knee Surgery*, vol. 29, no. 02, pp. 169–178, 2015.

[25] J. Gonzales, S. T. Løvald, E. C. Lau, and K. L. Ong, “Risk of opioid-related adverse events after primary and revision total knee arthroplasty,” *Journal of Surgical Orthopaedic Advances*, vol. 27, no. 02, pp. 148–154, 2018.

[26] R. K. Elmallah, M. Chuhtai, A. Khlopas et al., “Pain control in total knee arthroplasty,” *Journal of Knee Surgery*, vol. 31, no. 06, pp. 504–513, 2018.

[27] J. H. Seo, S. S. Seo, D. H. Kim, B. Y. Park, C. H. Park, and O. G. Kim, “Does combination therapy of popliteal sciatic nerve block and adductor canal block effectively control early postoperative pain after total knee arthroplasty?” *Knee Surgery and Related Research*, vol. 29, no. 4, pp. 276–281, 2017.

[28] U. Grevstad, O. Mathiesen, L. S. Valentiner, P. Jaeger, K. L. Hilsted, and J. B. Dahl, “Effect of adductor canal block versus femoral nerve block on quadriceps strength, mobilization, and pain after total knee arthroplasty: a randomized, blinded study,” *Regional Anesthesia and Pain Medicine*, vol. 40, no. 1, pp. 3–10, 2015.

[29] P. Jaeger, Z. J. H. M. Kocielnik-Nielsen, H. M. Schroer et al., “Adductor canal block for postoperative pain treatment after revision knee arthroplasty: a blinded, randomized, placebo-controlled study,” *PLoS One*, vol. 9, no. 11, Article ID e111951, 2014.
[30] M. U. Vora, T. A. Nicholas, C. A. Kassel, and S. A. Grant, “Adductor canal block for knee surgical procedures: review article,” *Journal of Clinical Anesthesia*, vol. 35, pp. 295–303, 2016.

[31] Y. Tao, S. Q. Zheng, T. Xu et al., “Median effective volume of ropivacaine 0.5% for ultrasound-guided adductor canal block,” *Journal of International Medical Research*, vol. 46, no. 10, pp. 4200–4213, 2018.

[32] C. Wang, Z. Zhang, W. Ma, H. Li, and X. du, “Locating adductor canal and quantifying the median effective volume of ropivacaine for adductor canal block by ultrasound,” *Journal of the College of Physicians and Surgeons—Pakistan: JCPSP*, vol. 31, no. 10, pp. 1143–1147, 2021.

[33] C. B. Christiansen, M. H. Madsen, C. Rothe, A. M. Andreasen, L. H. Lundstrom, and K. H. W. Lange, “Volume of ropivacaine 0.2% and sciatic nerve block duration: a randomized, blinded trial in healthy volunteers,” *Acta Anaesthesiologica Scandinavica*, vol. 64, no. 2, pp. 238–244, 2020.

[34] A. M. Monahan, J. F. Sztain, B. Khatibi et al., “Continuous adductor canal blocks: does varying local anesthetic delivery method (automatic repeated bolus doses versus continuous basal infusion) influence cutaneous analgesia and quadriceps femoris strength? A randomized, double-masked, controlled, split-body volunteer study,” *Anesthesia and Analgesia*, vol. 122, no. 5, pp. 1681–1688, 2016.

[35] C. Veal, D. B. Auyong, N. A. Hanson, C. J. Allen, and W. Strodtbeck, "Delayed quadriceps weakness after continuous adductor canal block for total knee arthroplasty: a case report," *Acta Anaesthesiologica Scandinavica*, vol. 58, no. 3, pp. 362–364, 2014.

[36] J. M. Neal, F. V. Salinas, and D. S. Choi, “Local anesthetic induced myotoxicity after continuous adductor canal block,” *Regional Anesthesia and Pain Medicine*, vol. 41, no. 6, pp. 723–727, 2016.

[37] W. Zhang, Y. Hu, Y. Tao, X. Liu, and G. Wang, "Ultrasound-guided continuous adductor canal block for analgesia after total knee replacement," *Chinese Medical Journal*, vol. 127, no. 23, pp. 4077–4081, 2014.

[38] M. K. Wasko, K. Bobecka-Wesołowska, R. Tomasiuk, and J. Kowalczewski, “Measurement of the inflammatory response in the early postoperative period after hip and knee arthroplasty,” *Clinical Chemistry and Laboratory Medicine*, vol. 53, no. 11, pp. 1785–1792, 2015.

[39] M. Purdy, M. Kokki, M. Anttila et al., “Does the rectus sheath block Analgesia reduce the inflammatory response biomarkers’ IL-1ra, IL-6, IL-8, IL-10 and IL-1β concentrations following surgery? A randomized clinical trial of patients with cancer and benign disease,” *Anticancer Research*, vol. 36, no. 6, pp. 3005–3011, 2016.

[40] K. M. Klifto, A. Elhelali, R. M. Payne, C. M. Cooney, M. A. Manahan, and G. D. Rosson, “Perioperative systemic nonsteroidal anti-inflammatory drugs (NSAIDs) in women undergoing breast surgery,” *Cochrane Database of Systematic Reviews*, vol. 1, no. 11, Article ID CD013290, 2021.

[41] S. F. Hu, Y. L. Zhang, W. Jiang et al., “Effects of preemptive analgesia with flurbiprofen on the blood sugar and interleukin-6 of patients after radical excision of breast cancer,” *Zhonghua Yixue Zazhi*, vol. 89, no. 39, pp. 2751–2753, 2009.

[42] T. Yang, H. Si, Y. Wu et al., “Efficacy of sequential treatment with adductor canal nerve block and cyclooxygenase 2 selective inhibitor after total knee arthroplasty,” *Zhongguo Xiu Fu Chong Jian Wai Ke Za Zhi = Zhongguo Xiyu Chongjian Waixi Zaizi = Chinese Journal Of Reparative and Reconstructive Surgery*, vol. 30, no. 9, pp. 1065–1071, 2016.