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A PROSPECTIVE RANDOMIZED CONTROLLED STUDY COMPARING PERIARTICULAR MULTIDRUG INFILTRATION AND EPIDURAL CATHETER USE IN TOTAL KNEE ARTHROPLASTY.

Orthopaedics

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ABSTRACT

Purpose: This study aimed to evaluate the effectiveness of periarticular multidrug infiltration (PMDI) and compare it with epidural catheter use. **Methods:** A total of 58 patients (58 joints) undergoing total knee arthroplasty participated in this single-center, prospective, parallel, randomized controlled trial. Preoperatively, patients were randomly assigned to either the PMDI or epidural catheter group. Postoperative pain was assessed using the visual analog scale (VAS) and narcotic consumption, while functional outcomes were evaluated through knee flexion range of motion (ROM), the day patients were able to perform the straight-leg raising (SLR) test, and the day they began using a cane. Laboratory data, including white blood cell (WBC) count and C-reactive protein (CRP) levels, were also analyzed. **Results:** There were no significant differences between the PMDI and epidural catheter groups in VAS scores, knee flexion ROM, the day patients could perform SLR, or the day they started using a cane. However, the PMDI group was able to perform SLR on postoperative day (POD) 1 ($p < 0.05$). The WBC count on POD 1 was significantly higher in the PMDI group ($p < 0.05$), while CRP levels were significantly lower in the PMDI group on POD 1 ($p < 0.01$), 3 ($p < 0.01$), and 5 ($p < 0.01$) compared to the epidural catheter group. The incidence of side effects was not significantly different between the groups. **Conclusion:** PMDI was as effective as epidural catheterization for pain management. A higher percentage of PMDI patients could perform SLR on POD 1, suggesting earlier functional recovery. Additionally, PMDI may reduce systemic inflammation, potentially due to the use of steroids.

KEYWORDS

epidural catheter, periarticular multidrug infiltration, total knee arthroplasty, visual analog pain scale.

INTRODUCTION:

The number of patients undergoing total knee arthroplasty (TKA) is steadily rising worldwide. As one of the most common invasive surgeries, TKA is often associated with significant postoperative pain, which can hinder rehabilitation and prolong hospital stays, making effective pain management crucial. While epidural catheters can alleviate postoperative pain, they are also linked to side effects such as postoperative nausea and vomiting (PONV), urinary retention, hypotension, itching, and motor block [1-3]. Female patients with a body mass index (BMI) below 20 kg/m² are especially prone to PONV [4]. These side effects can disrupt recovery, extend hospital stays, and even increase the risk of complications like pulmonary thromboembolism, urinary tract infections, and pneumonia[5-8]. Periarticular multidrug infiltration (PMDI) has emerged as an alternative, reducing narcotic use and improving functional outcomes in patients undergoing TKA and total hip arthroplasty[9-10]. However, while PMDI has been frequently studied in TKA, there are limited reports that simultaneously evaluate pain, functional outcomes, and laboratory results. This study aims to compare the efficacy of PMDI with that of epidural catheter use in TKA, hypothesizing that PMDI will provide superior pain control, faster recovery, and fewer side effects than epidural catheters.

MATERIALAND METHODS

Participants:

To achieve 80% power in detecting a moderate effect size ($d = 0.5$) for the t-test between two dependent means, we calculated that 27 participants per group would be necessary. A total of 58 patients (30 in the PMDI group and 28 in the epidural catheter group) were recruited between May 2023 and August 2024. Inclusion criteria were patients diagnosed with osteoarthritis who underwent primary TKA between May 2022 and March 2023. Exclusion criteria included patients under 20 years old, those with prior ipsilateral knee surgery, a history of lumbar surgery, or conditions such as rheumatoid arthritis, renal failure, dementia, or mental impairment. After screening 8 patients, 58 were enrolled in the study. Ethical approval was obtained from the institution's review board.

Randomization and Intervention:

This was a single-center, prospective, parallel, randomized controlled trial, conducted in accordance with the Consolidated Standards of Reporting Trials (CONSORT) guidelines. After informed consent, patients undergoing TKA between May 2022 and March 2023were randomly assigned to either the PMDI or epidural catheter group using a computer-generated randomization table. A separate orthopedic surgeon, uninvolved in the randomization process, assessed eligibility to ensure allocation concealment. Surgeons involved in assigning the patients were responsible for implementing the treatments.

In the PMDI group, patients received an injection containing 150 mg of 0.2% ropivacaine, 0.2 mg of adrenaline, 40 mg of methylprednisolone, and 10 mL of saline into the knee capsule. An additional 150 mg of 0.2% ropivacaine, 0.2 mg of adrenaline, and 10 mL of saline were injected into the muscles and subcutaneous tissues before closing the wound.

For the epidural catheter group, the catheter was inserted at the L1-2 or L2-3 level using loss of resistance to air to locate the epidural space, followed by a test dose of 1% lidocaine. During wound closure, an 8 mL epidural bolus of 0.2% ropivacaine was given, and continuous infusion of 0.2% ropivacaine (296 mL) with fentanyl (4 mL) was started, at a rate of 4 mL/h. The catheter was removed two days after surgery.

Surgical Procedure:

The surgery was performed using a parapatellar approach by three experienced surgeons. After bone cuts on the distal femur, proximal tibia, and patella, cemented components were implanted. A tourniquet was used in all cases during implantation. Patients were allowed to bear weight as tolerated starting the day after surgery.

Outcomes:

The primary outcome measure was pain assessment, while secondary outcomes included functional performance and laboratory data. Pain was measured using a visual analog scale (VAS), ranging from 0 mm (no pain) to 100 mm (worst pain), recorded daily during rest for seven days post-surgery. Narcotic consumption was documented until postoperative day (POD) 3.

Functional outcomes included knee flexion range of motion (ROM), the day patients could perform a straight leg raise (SLR), the percentage of patients able to perform SLR on POD 1, and the day patients began using a cane. ROM and SLR were measured in the morning, with patients flexing their knees and performing SLR in a supine position. The SLR test was considered successful if the patient could lift their leg and hold the position for at least 3 seconds.

Laboratory data, including white blood cell (WBC) count and C-reactive protein (CRP) levels, were collected on PODs 1, 3, 5, and 7. Side effects, such as PONV, numbness, infection, and itching, were also recorded.

Statistical Analysis:
Data were analyzed using SPSS version 25. Baseline demographics and characteristics were compared between groups. Paired t-tests were used to analyze VAS scores, narcotic consumption, ROM, laboratory data, and the time to cane use. Fisher's exact test was employed to assess the percentage of patients performing SLR on POD 1 and to compare side effects. A significance level of $p < 0.05$ was applied for all tests.

RESULTS

Patient Population:
All patients in both groups completed follow-up. Initially, 82 patients were enrolled in the study, but only 58 were included in the final analysis—30 in the PMDI group and 28 in the epidural catheter group. Baseline characteristics, including sex, age, body mass index, and preoperative knee flexion range of motion (ROM), were comparable between the two groups.

Clinical and Functional Outcomes:
The visual analog scale (VAS) scores for pain in the PMDI and epidural catheter groups showed no significant difference (Figure 1). Similarly, narcotic consumption did not differ significantly between the two groups. In terms of functional outcomes, there was no significant difference in the postoperative ROM of knee flexion (Figure 2). Although the day patients were able to perform straight leg raises (SLR) was comparable between the groups, a significantly higher percentage of patients in the PMDI group could perform SLR on postoperative day (POD) 1 ($p < 0.05$). There was no significant difference in the day patients started using a cane between the PMDI and epidural catheter groups.

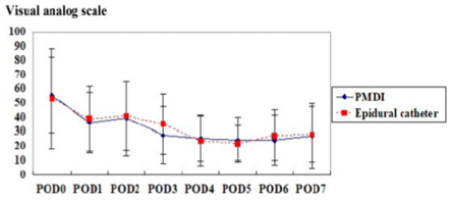

Figure 1

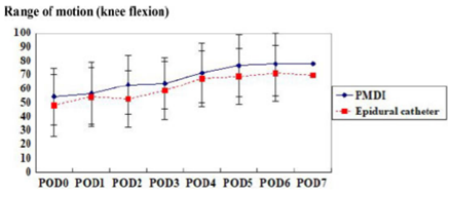

Figure 2

Regarding laboratory data, the white blood cell (WBC) count on POD 1 was significantly higher in the PMDI group compared to the epidural catheter group ($p < 0.05$) (Figure 3). Conversely, C-reactive protein (CRP) levels were significantly lower in the PMDI group on PODs 1 ($p < 0.01$), 3 ($p < 0.01$), and 5 ($p < 0.01$) compared to the epidural catheter group (Figure 3).

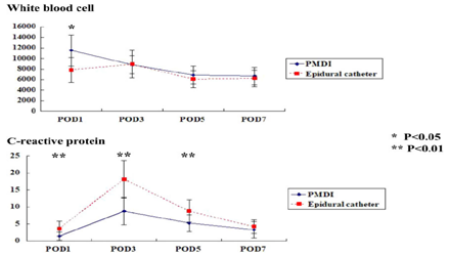

Figure 3

In terms of side effects, two patients in the epidural catheter group experienced numbness, and two patients had vomiting. In contrast, only one patient in the PMDI group experienced transient nerve palsy. However, the overall incidence of side effects did not differ significantly between the two groups.

DISCUSSION

In this study, we evaluated the effectiveness of periarticular multidrug infiltration (PMDI) compared to epidural catheter placement in patients undergoing total knee arthroplasty (TKA). Our results indicated no significant differences in postoperative pain, as assessed by VAS scores and narcotic consumption, between the PMDI and epidural catheter groups. Similarly, there were no notable differences in range of motion (ROM) or the timing of straight leg raise (SLR) performance between the two groups. However, patients in the PMDI group were able to perform SLR earlier on postoperative day (POD) 1 compared to those in the epidural catheter group.

In terms of laboratory outcomes, the PMDI group exhibited significantly higher white blood cell (WBC) counts on POD 1, while C-reactive protein (CRP) levels were significantly lower in the PMDI group on PODs 1, 3, and 5 compared to the epidural catheter group. The formulation of PMDI can vary widely across different studies. In our research, we utilized ropivacaine and methylprednisolone for PMDI. Ropivacaine, a local anesthetic, has a pharmacokinetic profile similar to that of bupivacaine, but it boasts a longer duration of action and a lower toxicity profile[11,12]. While previous studies commonly employed 300–400 mg of bupivacaine[12,13], we administered 300 mg of ropivacaine.

Salerno and Hermann[14] reported that local corticosteroid injections in musculoskeletal tissues and joints are generally safe and can enhance pain relief and functional recovery. Additionally, Tsukuda et al.[15] found that patients receiving PMDI with corticosteroids had significantly lower pain scores than those who received PMDI without corticosteroids, suggesting that the inclusion of corticosteroids may enhance the efficacy of PMDI for postoperative pain management.

Despite the lack of significant differences in VAS scores between the two groups, the content of PMDI varied across studies. We deliberately avoided the use of opioids due to their potential to induce nausea, vomiting, and itching, as well as the use of ketoprofen because of its possible adverse effects on renal function and risk of gastric ulceration. These factors could potentially influence our findings.

Few studies have explored the relationship between PMDI and laboratory data. Although we did not directly attribute changes in laboratory data to PMDI, the higher WBC count on POD 1 and lower CRP levels in the PMDI group suggest an impact. Similarly, Ishida et al. demonstrated that CRP levels were significantly lower in the PMDI group compared to those receiving continuous femoral nerve blocks from PODs 1–7. We hypothesize that corticosteroid injections may facilitate the release of neutrophils from the bone marrow into the bloodstream while simultaneously suppressing inflammation, as evidenced by the reduced CRP levels.

Our results showed that 67% (20 out of 30) of the patients in the PMDI group were able to perform SLR on POD 1 ($p < 0.02$), while only 32% (9 out of 28) of the patients in the epidural catheter group achieved this milestone. This indicates that PMDI provided comparable pain control to that of the epidural catheter while demonstrating superior functional outcomes regarding SLR performance. Therefore, PMDI appears to be a more effective option for TKA compared to the epidural catheter.

This study has several limitations. First, the surgeries were performed by three different surgeons, which may have introduced variability in the results. However, all surgeons had more than ten years of experience in orthopedic procedures, and the surgical techniques were standardized. Second, the study lacked blinding, which may have led to potential bias regarding treatment awareness among patients and researchers.

CONCLUSION

Our findings indicate that periarticular multidrug infiltration (PMDI) is as effective as epidural catheter placement for pain management in patients undergoing total knee arthroplasty (TKA). Additionally, PMDI demonstrated superior functional outcomes, with a higher percentage of patients able to perform straight leg raises on postoperative day 1. Furthermore, the use of steroids in PMDI resulted in reduced inflammation compared to epidural catheterization.

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