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Meta-analysis of the analgesic effect and adverse reactions of ultrasound-guided adductor canal block combined with popliteal artery and posterior capsule space block in patients undergoing total knee arthroplasty

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Abstract: *The purpose of this article is to evaluate the role of ultrasound-guided adductor tube block combined with popliteal artery and posterior capsule space block in postoperative pain relief after total knee arthroplasty. Retrieve PubMed EMBASE,Web of Science,A randomized controlled trial (RCT) comparing the effects of iPACK combined with ATB on postoperative analgesia in TKA using the Chinese Biomedical Literature Database (CBM), Chinese Science and Technology Journal Full text Database (VIP), Chinese Journal Full text Database (CNKI), and Wanfang Database. The retrieval time is from the establishment of the database to April 2024. Two researchers screened literature and extracted data based on inclusion criteria, while two evaluators independently evaluated the quality of the included literature using RevMan5.3 for meta-analysis. As a result, a total of 442 patients were included in 4 RCTs. Compared with the Control group, the experimental group showed a significant decrease at the resting pain score at 12 h after surgery (MD=-1.13; 95%CI -1.20 ~ -1.06, P<0.00001) , the resting pain score at 24h after surgery (MD=-0.11; 95% CI-0.17~ -0.04, P=0.0001) , the resting pain score at 48h after surgery (MD=-0.09; 95% CI-0.17 ~ -0.02, P=0.01) , the exercise pain score at 12 h after surgery (MD=-1.10; 95%CI -1.17 ~ -1.02, P<0.00001) , the exercise pain score at 24h after surgery (MD=-0.33; 95% CI-0.38 ~ -0.27, P<0.00001), the exercise pain score at 48h after surgery (MD=-0.33; 95% CI-0.39~ -0.27, P<0.00001) , 72h postoperative exercise state pain scores (MD=-0.21; 95%CI -0.42 ~ -0.01, P=0.04) , the number of times the analgesic pump pressed (MD=-1.23; 95% CI-1.33~ -1.13, P<0.00001) , the first time to get out of bed (MD=-11.68; 95% CI-13.35~ -10.02, P<0.00001). Compared with the Control group, the experimental group showed a significant increase at the knee joint range of motion at 24hours after surgery (MD=6.92; 95%CI 3.33 ~ 10.51, P=0.0002), the knee joint range of motion at 48hours after surgery (MD=6.92; 95%CI 3.62 ~ 10.22, P<0.00011). There is no significant difference at 72h postoperative resting state pain scores between the two groups of patients (MD=-0.18; 95%CI -0.38 ~ 0.02, P=0.08), the incidence of nausea and vomiting (RR=0.64, 95% CI 0.30~1.37, P=0.25) , the knee joint range of motion at 72hours after surgery (MD=1.69; 95%CI -1.63 ~ 5.01, P=0.32). Compared to ACB, The combination of iPACK block and ACB can more effectively alleviate postoperative pain after total knee arthroplasty, which is beneficial for patients to get out of bed early and increase knee joint range of motion. It is safe and effective for postoperative analgesia in TKA.*

Keywords: *Ultrasound; adductor tube block; popliteal artery combined with posterior capsule space block; total knee arthroplasty; analgesia; Meta analysis*

1. Introduction

Total knee arthroplasty is an effective treatment for end-stage knee osteoarthritis. However, due to the traumatic nature of the surgery, patients often experience intolerable pain after surgery [1]. However, some studies have shown that the percentage of patients experiencing moderate to severe pain after TKA is as high as 30% to 60%. In addition, the majority of patients undergoing this type of surgery are elderly,

ISSN 2616-5791 Vol.5, Issue 6: 8-17, DOI: 10.25236/AJMHS.2024.050602

and many of them have co-morbidities, so postoperative trauma and pain stimulation have an even greater impact on these patients, and even serious postoperative complications may occur [2]. Therefore, a comprehensive postoperative pain management strategy for TKA is very important, which can not only reduce the pain of patients and promote the early recovery of joint function, but also shorten the hospitalization time and improve patient satisfaction.Under the concept of accelerated rehabilitation surgery (ERAS), regional block is the main mode of analgesia after TKA. Nerve block is the injection of local anesthetics into the periphery of nerve trunks, plexuses, and ganglia to block nerve impulse conduction so that the anesthetic effect can be applied to the innervated area of the nerve [3]. Compared with femoral nerve block, ACB is not only efficient in analgesia, but also effective in preserving muscle strength, but the use of adductor canal block alone can only inhibit the pain in the anterior part of the knee joint better, and the analgesic effect is not good for the pain in the posterior part of the knee joint [4].IPACK block is an emerging nerve block technique in clinical practice, which impregnates the popliteal plexus nerve, the nerve innervating sensation in the posterior part of the knee, by injecting local anesthetic, and has good analgesic effect in combination with the adductor canal block [5].Therefore, the aim of this study was to include recent relevant literature to analyze the postoperative analgesic effects and adverse effects of ACB combined with Ipack block in patients with total knee replacement, and to provide relevant evidence for the popularization and application of this technique in the clinic.

2. Materials and Methods

2.1 Literature search

Retrieve the Chinese Biomedical Literature Database (CBM), Chinese Science and Technology Journal Full text Database (VIP), Chinese Journal Full text Database (CNKI), and Wanfang Database using Chinese search terms such as "knee joint", "nerve block", "postoperative analgesia", "popliteal artery posterior capsule space block", "adductor tube block", and "ultrasound", using a combination of free words and subject words. Retrieve the Chinese Biomedical Literature Database (IPM), Chinese Science and Technology Journal Full text Database (VIP), Chinese Journal Full text Database (CNKI), and Wanfang Database using English search terms such as "knee joint", "nerve block", "postoperative analgesia", "popliteal artery posterior capsule space block", "adductor tube block", and "ultrasound", Word search PubMed EMBASE,Web of Science. The retrieval time is from the establishment of the database to May 2024, with no language restrictions. At the same time, track the references that have been included in the literature to obtain relevant information that has not been retrieved.

2.2 Inclusion and Exclusion Criteria

2.2.1 Research type

Randomized controlled trial (RCT).

2.2.2 Research subjects

(1) Selected TKA; ② No nausea, vomiting, skin itching, or history of drug allergies before surgery; ③ No history of severe center of gravity, lung, liver, kidney and other diseases; ④ No history of long-term use of sedative or analgesic drugs.

2.2.3 Intervention measures

Experimental group: received iPACK block combined with ACB; Control group: Received ACB.

2.2.4 Evaluation indicators

The main indicators are pain scores for resting and moving states at 12h, 24h, 48h, and 72h after surgery. The secondary indicators were the number of times the analgesic pump was pressed, the time of first getting out of bed, knee joint range of motion at 24h, 48h, and 72h after surgery, and the incidence of postoperative nausea and vomiting.

2.2.5 Exclusion criteria

Exclude non randomized controlled trials, reviews, and literature with no available data, and exclude low-quality literature (Jadad score ≤ 3).

ISSN 2616-5791 Vol.5, Issue 6: 8-17, DOI: 10.25236/AJMHS.2024.050602

2.3 Data Extraction

Literature screening is conducted independently by two evaluators. Firstly, by reading the title and abstract, literature that clearly does not meet the inclusion criteria is excluded. If it is difficult to make a judgment, read the entire text in detail. Whether all literature should be included is decided jointly by two evaluators. If there are different opinions, a third party should be consulted for a ruling. Extract the following information from literature that meets the inclusion criteria using a unified data extraction table: title, author, publication time, number of included cases, gender, BMI, ASA grading, surgical duration, concentration and dosage of local anesthetic drugs, postoperative pain scores at various time points, postoperative adverse reactions, etc. During the data extraction process, data presented in the form of median and range or mean ± standard error shall be uniformly converted to mean ± standard deviation according to the method provided in the Cochrane system evaluator manual.

2.4 Literature quality evaluation

According to the improved Jadad scoring system, two evaluators independently evaluated the quality of the included literature, including the randomization method, allocation concealment method, blinding method, and the presence or absence of follow-up. If there are different opinions, a third party should be consulted for a ruling. The evaluation content includes random sequence generation, allocation concealment, blinding, withdrawal or withdrawal. The score is 1-7 points. A score of 1-3 indicates low quality, while a score of 4-7 indicates high quality.

2.5 Statistical analysis

Perform meta-analysis using RevMan5.3 provided by Cochrane Collaboration Network. The heterogeneity among the included research results was tested using x^2. There is statistical homogeneity ($P \geq 0.05$) among the studies, and a fixed effects model is used to analyze each study; If there is statistical heterogeneity ($P<0.05$) among studies, analyze the sources of heterogeneity, conduct subgroup analysis or sensitivity analysis. If the cause of heterogeneity is not found, use a random effects model for analysis. The relative risk ratio is used for counting data and measuring data, respectively, RR and mean difference, MD) serves as the merging statistic. Each effect size is expressed as 95% CI. If the provided data cannot be subjected to meta-analysis, descriptive analysis will be used.

3. Results

3.1 Literature search results

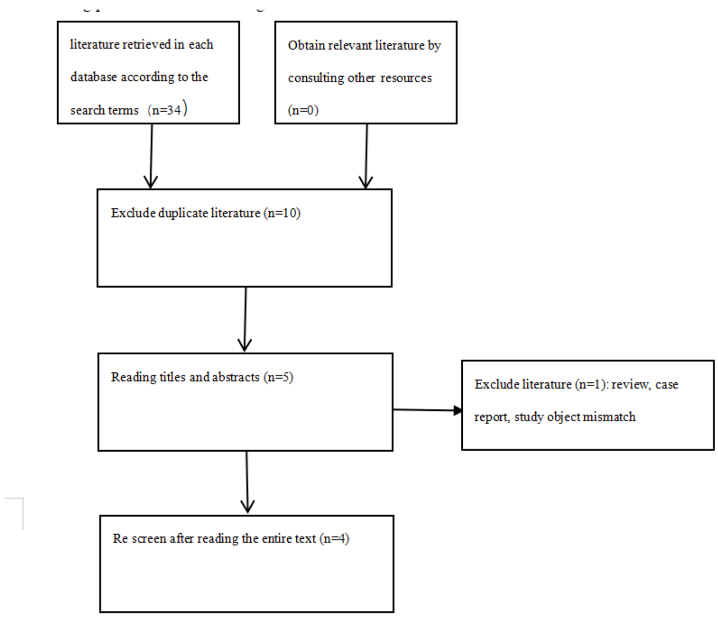


Figure 1: Literature Screening Process

ISSN 2616-5791 Vol.5, Issue 6: 8-17, DOI: 10.25236/AJMHS.2024.050602

A total of 34 relevant literature were retrieved. After screening and excluding irrelevant literature, a total of 4 articles[6-9] were included in the meta-analysis, including 442 patients. The literature screening process is shown in Figure 1.

3.2 Basic information and bias risk assessment of included literature

The basic characteristics of the included literature are shown in Table 1; The risk assessment of literature bias is shown in Figure 2.

Table 1: Basic characteristics of included studies

literature	sample size		Age (years)		Gender (male/female)		BMI(kg/cm^2)		ASA classification (Level I/II/ III)		Surgical time (min)		Local anesthetic dosage		Outcome indicators
	Experimental group	Control group	Experimental group	Control group	Experimental group	Control group	Experimental group	Control group	Experimental group	Control group	Experimental group	Control group	Experimental group	Control group	
Huang LH 2023 [6]	36	36	68. 11±8. 07	68. 22±7. 23	4 / 32	5 / 31	23. 85±2. 74	24. 39±2. 93	3/ 30/ 3	4 / 30 / 2	106. 81±17. 04	108. 33±24. 20	0.25% ropivacaine 30ml	0.25% ropivacaine 15ml	1-8，11-14
Zhang Y 2023 [7]	41	39	63.96±1.17	64.52±1.25	23/18	22/17	22.85±1.19	23.05±1.23					0.375% ropivacaine 35ml	0.375% ropivacaine 15ml	1-3，5-7，9-10，14
Shi L 2023 [8]	100	100	66.83±7.62	67.14±7.50	64/36	62/38	21.74±1.58	21.80±1.47	0 / 83 /17	0 / 86 /174	96.47±6.21	95.82±6.56	0.2% ropivacaine 35ml	0.2% ropivacaine 20ml	1-3、5-7、9-10、14
Luo K 2024 [9]	45	45	74.85±5.61	74.13±5.87	14/31	12/33	29.51±0.97	29.44±1.01					0.3% ropivacaine 38ml	0.3% ropivacaine 18ml	2-4、6-13

1. 2, 3, and 4 are the resting state pain scores at 12h, 24h, 48h, and 72h after surgery, respectively; 5. 6, 7, and 8 are pain scores for postoperative movement status at 12h, 24h, 48h, and 72h, respectively; 9 is the number of times the analgesic pump pressed; 10 is the first time to get out of bed; 11. 12 and 13 are knee joir range of motion at 24, 48, and 72 hours after surgery; 14 is the incidence of postoperative nausea and vomiting.

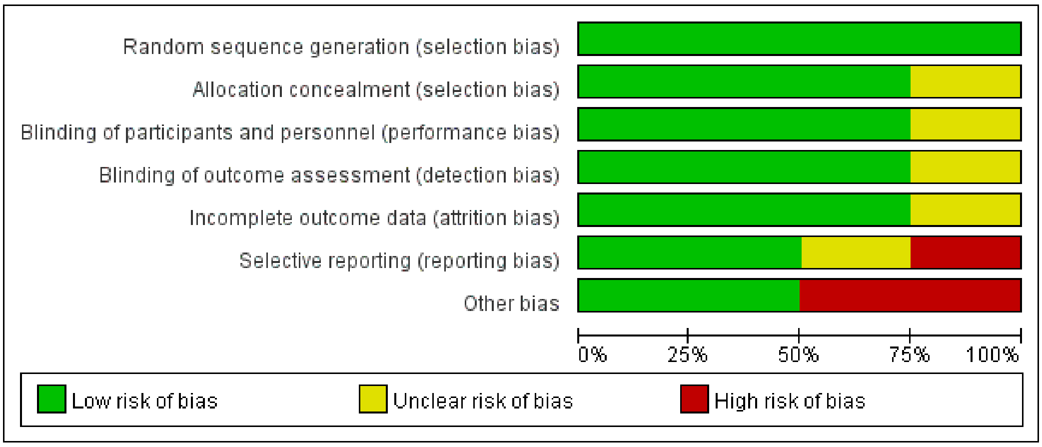


Figure 2: Bias Risk Assessment Chart

3.3 Results of meta-analysis

3.3.1 Resting state pain scores of patients in the two groups at different time points after surgery

Three literatures [6-8] compared the resting pain score at 12 h after surgery, showing significant heterogeneity (I^2=97%, P<0.00001). Using the random effects model, the results of meta-analysis showed that the resting pain score at 12 h after surgery in the experimental group was significantly lower than that in the control group (MD=-1.13; 95%CI -1.20 ~ -1.06, P<0.00001) (Figure 3-A).

Four literatures [6-9] compared the resting pain score at 24h after surgery, showing significant heterogeneity (I^2=93%, P<0.00001). Using the random effects model, the results of meta-analysis showed that the resting pain score at 24h after surgery in the experimental group was significantly lower than that in the control group (MD=-0.11; 95% CI-0.17~ -0.04, P=0.0001) (Figure 3-B).

Four literatures [6-9] compared the resting pain score at 48h after surgery, showing significant heterogeneity (I^2=88%, P<0.00001). Using the random effects model, the results of meta-analysis showed that the resting pain score at 48h after surgery in the experimental group was significantly lower than that in the control group (MD=-0.09; 95% CI-0.17 ~ -0.02, P=0.01) (Figure 3-C).

Two literatures [6,9] compared 72h postoperative resting state pain scores without significant heterogeneity (I^2=0%, P=0.92). Using the fixed-effect model, meta-analysis results showed that there is no significant difference at 72h postoperative resting state pain scores between the two groups of patients (MD=-0.18; 95%CI -0.38 ~ 0.02, P=0.08) (Figure 3-D).

ISSN 2616-5791 Vol.5, Issue 6: 8-17, DOI: 10.25236/AJMHS.2024.050602

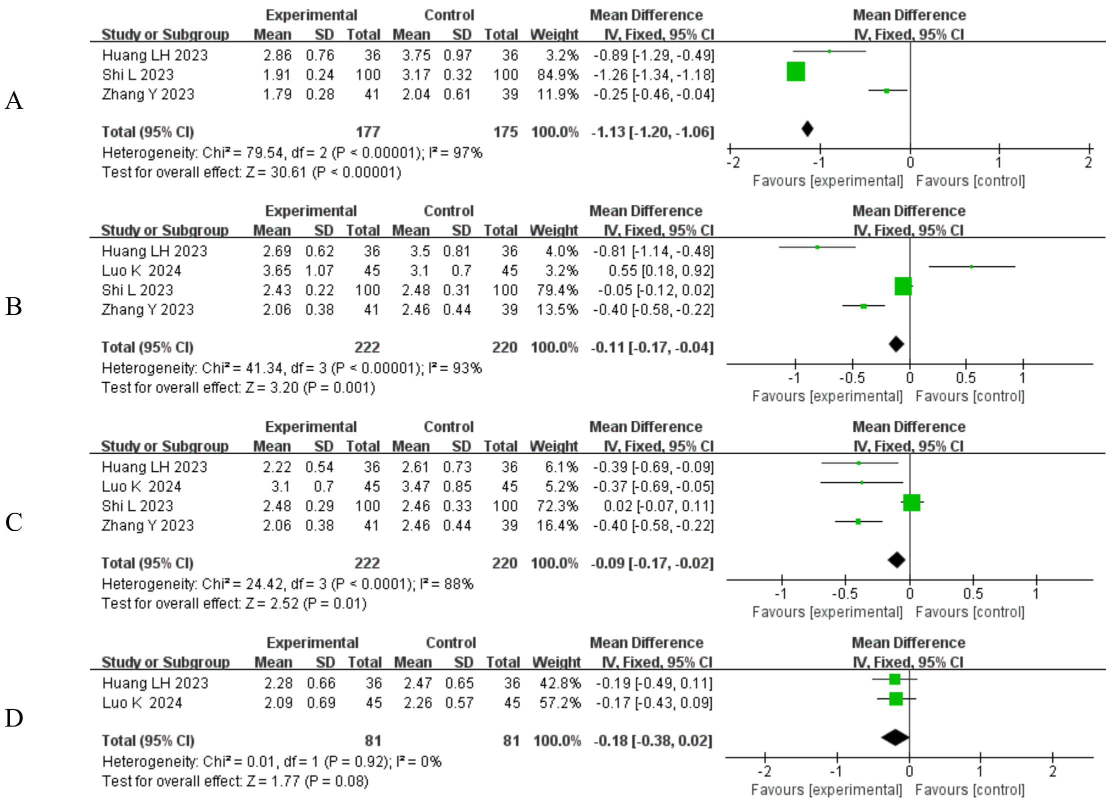


Figure 3: Resting state pain scores at different time points after surgery

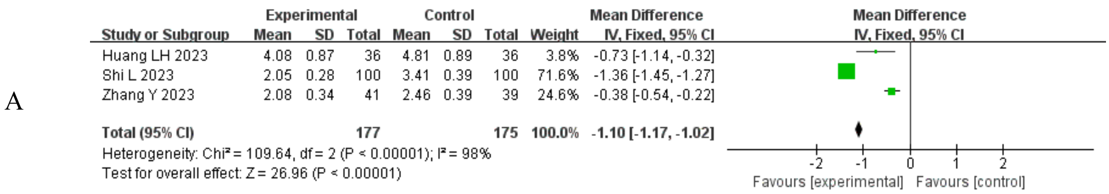
3.3.2 Exercise state pain scores of patients in the two groups at different time points after surgery

Three literatures [6-8] compared the exercise pain score at 12 h after surgery, showing significant heterogeneity (I^2=98%, P<0.00001). Using the random effects model, the results of meta-analysis showed that the exercise pain score at 12 h after surgery in the experimental group was significantly lower than that in the control group (MD=-1.10; 95%CI -1.17 ~ -1.02, P<0.00001) (Figure 4-A).

Four literatures [6-9] compared the exercise pain score at 24h after surgery, showing significant heterogeneity (I^2=97%, P<0.00001). Using the random effects model, the results of meta-analysis showed that the exercise pain score at 24h after surgery in the experimental group was significantly lower than that in the control group (MD=-0.33; 95% CI-0.38 ~ -0.27, P<0.00001) (Figure 4-B).

Four literatures [6-9] compared the exercise pain score at 48h after surgery, showing significant heterogeneity (I^2=97%, P<0.00001). Using the random effects model, the results of meta-analysis showed that the exercise pain score at 48h after surgery in the experimental group was significantly lower than that in the control group (MD=-0.33; 95% CI-0.39~ -0.27, P<0.00001) (Figure 4-C).

Two literatures [6,9] compared 72h postoperative exercise state pain scores without significant heterogeneity (I^2=37%, P=0.21). Using the fixed-effect model, meta-analysis results showed that the exercise pain score at 72h after surgery in the experimental group was significantly lower than that in the control group (MD=-0.21; 95%CI -0.42 ~ -0.01, P=0.04) (Figure 4-D).



ISSN 2616-5791 Vol.5, Issue 6: 8-17, DOI: 10.25236/AJMHS.2024.050602

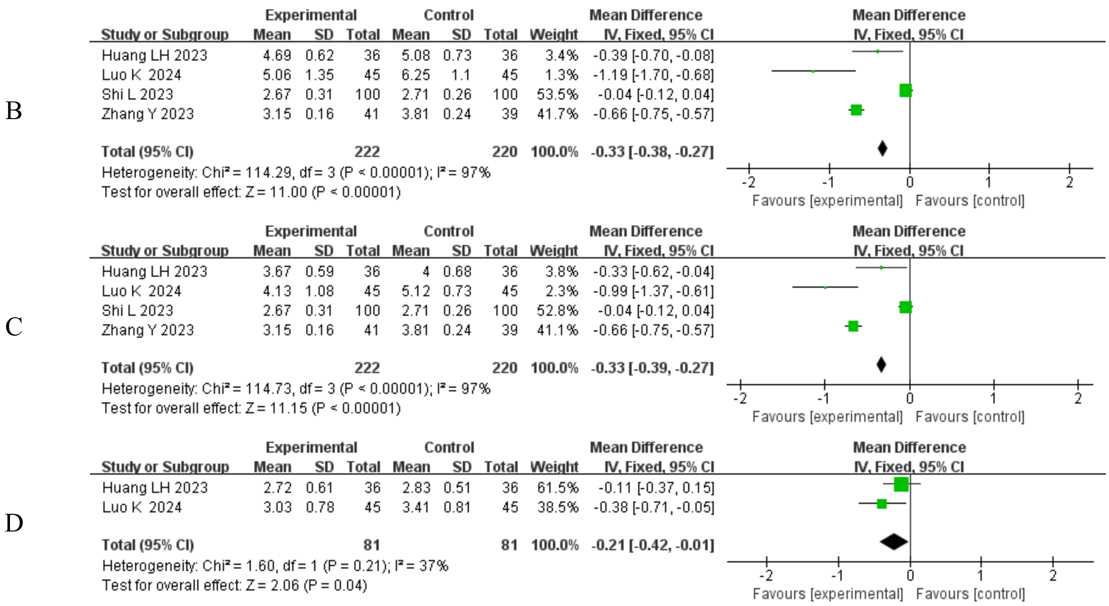


Figure 4: Exercise state pain scores at different time points after surgery

3.3.3 The number of times the analgesic pump pressed and the first time to get out of bed

Three literatures [7-9] compared the number of times the analgesic pump pressed, showing significant heterogeneity (I^2=81%, P=0.006). Using the random effects model, the results of meta-analysis showed that the number of times the analgesic pump pressed in the experimental group was significantly lower than that in the control group (MD=-1.23; 95% CI-1.33~ -1.13, P<0.00001) (Figure 5-A).

Three literatures [7-9] compared the first time to get out of bed, showing significant heterogeneity (I^2=98%, P<0.00001). Using the random effects model, the results of meta-analysis showed that the first time to get out of bed in the experimental group was significantly lower than that in the control group (MD=-11.68; 95% CI-13.35~ -10.02, P<0.00001) (Figure 5-B).

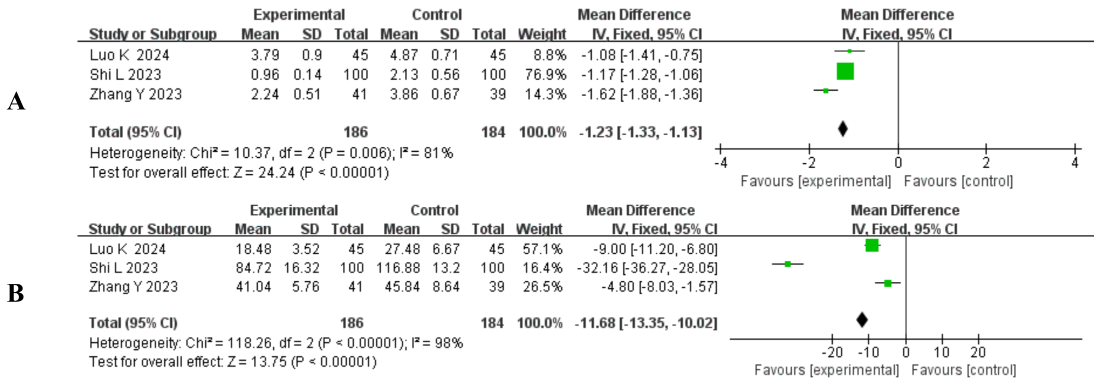


Figure 5: The number of times the analgesic pump pressed and the first time to get out of bed

3.3.4 Knee joint range of motion at different time points

Two literatures [6,9] compared the knee joint range of motion at 24hours after surgery;, showing significant heterogeneity (I^2=98%, P<0.00001). Using the random effects model, the results of meta-analysis showed that the knee joint range of motion at 24hours after surgery in the experimental group was significantly increased than that in the control group (MD=6.92; 95%CI 3.33 ~ 10.51, P=0.0002) (Figure 6-A).

Two literatures [6,9] compared the knee joint range of motion at 48hours after surgery;, showing significant heterogeneity (I^2=0%, P=0.32). Using the fixed effects model, the results of meta-analysis showed that the knee joint range of motion at 48hours after surgery in the experimental group was significantly increased than that in the control group (MD=6.92; 95%CI 3.62 ~ 10.22, P<0.00011) (Figure 6-B).

Two literatures [6,9] compared the knee joint range of motion at 72hours after surgery;, showing

ISSN 2616-5791 Vol.5, Issue 6: 8-17, DOI: 10.25236/AJMHS.2024.050602

significant heterogeneity (I^2=32%, P=0.22). Using the fixed effects model, the results of meta-analysis showed that there is no significant difference at the knee joint range of motion at 72hours after surgery between the two groups of patients (MD=1.69; 95%CI -1.63 ~ 5.01, P=0.32) (Figure 6-C).

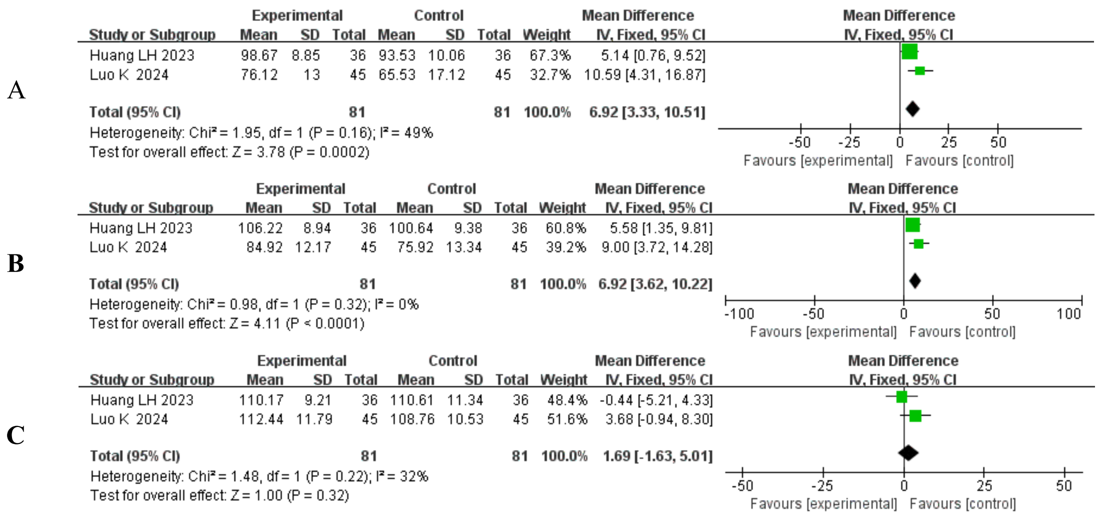


Figure 6: Knee joint range of motion at different time points

3.3.5 The incidence of postoperative nausea and vomiting

Three articles [6-8] compared the incidence of nausea and vomiting without significant heterogeneity (I^2=0%, P=0.94). Using a fixed effects model, meta-analysis results showed that there is no significant difference at the knee joint range of motion at the incidence of nausea and vomiting between the two groups of patients (RR=0.64, 95% CI 0.30~1.37, P=0.25) (Figure 7).

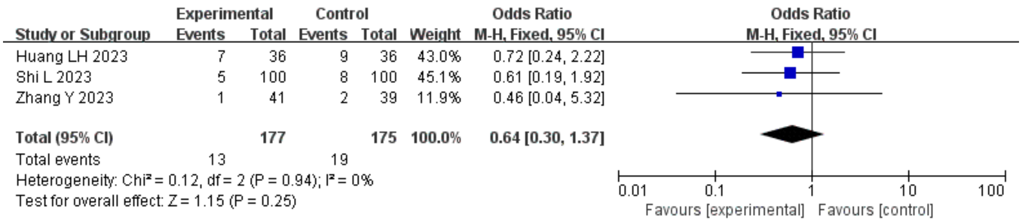


Figure 7: The incidence of postoperative nausea and vomiting

3.3.6 Publication bias

A funnel plot was drawn based on the resting pain score at 24h after surgery. The funnel plot was symmetrically distributed, and the results indicated a relatively small publication bias. (Figure 8)

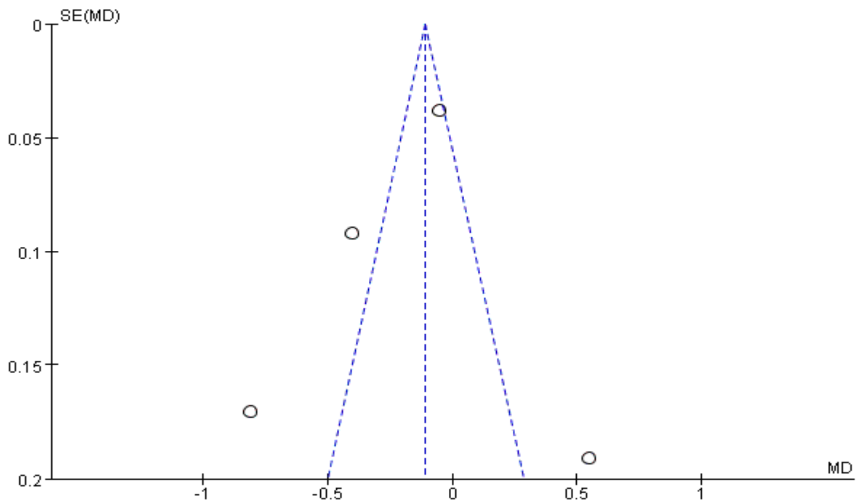


Figure 8: Funnel plot of publication bias in the resting pain score at 24h after surgery

4. Discussion

TKA is one of the most effective surgical procedures available for the treatment of severe or end-stage knee disease. The knee joint is the largest and most complex joint in the human body, with rich neuromuscular and vascular innervation, which leads to moderate to severe pain after TKA, seriously affecting the early mobility and rehabilitation of the joint after surgery, the total hospitalization time, as well as patient satisfaction and even the overall therapeutic effect [10]. Accelerated rehabilitation perioperative pain management guidelines pointed out that orthopedic surgery patients need to start functional exercise as early as possible after surgery, and the management of postoperative pain, especially pain during exercise, is particularly important [11]. Multimodal analgesia is considered to be the ideal analgesic method after TKA, including epidural analgesia, self-controlled opioid analgesia, oral analgesics and peripheral nerve block analgesia. Although the first three analgesic methods have better analgesic effect, they are often accompanied by higher incidence of adverse reactions, such as postoperative nausea and vomiting, respiratory depression, urinary retention caused by opioids, epidural hematoma and hypotension caused by epidural analgesia, and insufficient analgesia due to the elimination of the first drug of oral analgesic drugs [12]. Therefore, nerve block is the most appropriate postoperative analgesic method for TKA under the current ERAS concept.

The innervation of the knee joint mainly originates from the femoral nerve and sciatic nerve, in which the femoral nerve and its branches innervate the anterior internal part of the knee joint, and the posterior part is innervated by the sciatic nerve. The commonly used ACB is to block the saphenous nerve, a major sensory branch of the femoral nerve, which is accomplished by injecting local anesthetic into the retractor canal. The muscle canal is surrounded by the femoral suture muscle, medial retractor muscle, long retractor muscle and large retractor muscle, and the block of this area can realize analgesia in the area controlled by the medial femoral nerve, most of the cutaneous nerves, saphenous nerve, posterior branch of the obturator nerve, and a few anterior branches of the obturator nerve. Therefore, the completion of saphenous nerve block in the retractor canal can realize most of the analgesia in the anterior medial knee joint.Femoral nerve block (FNB) combined with sciatic nerve block (SNB) is used for postoperative analgesia after TKA with remarkable effect, and it has become one of the commonly used peripheral nerve blocks after TKA [13]. However, FNB will weaken the quadriceps muscle strength, and SNB will lead to foot drop, which will affect the early postoperative movement of patients [14-15].ACB can achieve similar analgesic effect as FNB without affecting the muscle strength of quadriceps muscle, and the effect of combined with SNB is better than that of ACB alone.However, the blockage of motor nerves will lead to foot drop, which will affect the early postoperative bed activities of patients[16-17].. IPACK block can selectively block the sensory branch of the posterior end of the knee joint without affecting the motor branch of the tibial nerve and common peroneal nerve, which can minimize the effect on muscle strength under the condition of adequate analgesia [18-20].There are fewer comparative studies on the effect of IPACK combined with ACB, so this study was conducted to find a more reasonable analgesia after TKA and to promote the patients' postoperative recovery by performing a meta-analysis of the analgesic regimen of this combined nerve block.

5. Conclusion

The results of this Meta-analysis suggest that compared with ACB alone, patients with IPACK block combined with ACB applied to total knee arthroplasty had significantly lower resting pain scores at 12 h postoperatively, 24 h postoperatively, and 48 h postoperatively, as well as significantly lower pain scores in the movement state at 12 h postoperatively, 24 h postoperatively, 48 h postoperatively, and 72 h postoperatively, and significantly fewer analgesic pump compressions, suggesting that The analgesic effect of ACB combined with IPACK is better than that of ACB alone, which may be due to the fact that IPACK block can diffuse local anesthetic drugs to the branch of the common peroneal nerve, tibial nerve branch and the off branch of the obturator nerve, thus blocking the nerve conduction function of the posterior aspect of the knee, increasing the analgesic effect of the posterior aspect of the knee, and it is more comprehensive for the analgesia of the pain after knee arthroplasty, which can be strengthened by combining with ACB. The combination with ACB can strengthen the analgesic effect [21].The patients in the experimental group got out of bed for the first time after the operation significantly earlier, and the range of knee joint activities increased significantly at 24 hours and 48 hours after the operation, indicating that IPACK block combined with ACB can better preserve the muscle strength of quadriceps muscle, reduce the impact on the patients' postoperative activities, and accelerate the postoperative recovery. There was no significant difference in resting state pain scores and knee range of motion between the two groups at 72h postoperatively, nor was there any significant difference in the incidence of adverse events such as nausea and vomiting.

The results of this study suggest that IPACK block combined with ACB can provide satisfactory analgesia after TKA, reduce the use of opioids and do not increase the incidence of related adverse events.IPACK block combined with ACB can also promote the recovery of quadriceps muscle strength, increase the range of motion of the knee joint, and promote the early recovery of the patients, improve the patients' satisfaction with the surgery and postoperative quality of life, and is a safe and effective analgesic method. It is a safe and effective analgesic method to improve patients' satisfaction with surgery and postoperative quality of life.

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