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Comparison of adductor canal block with periarticular infiltration analgesia in total knee arthroplasty

A meta-analysis of randomized controlled trials

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Abstract

Background: Total knee arthroplasty (TKA) is accompanied by moderate to severe postoperative pain. Multimodal analgesia, such as femoral nerve block, periarticular infiltration analgesia (PIA), and patient-controlled intravenous analgesia, have been used for postoperative analgesia. Recently, randomized controlled trials have compared the efficacy of the adductor canal block (ACB) and the PIA in patients undergoing TKA. However, there is no definite answer as to the efficacy and safety of the ACB compared with the PIA.

Method: Randomized controlled trials about relevant studies were searched from PubMed (1996 to May 2019), Embase (1980 to May 2019), and Cochrane Library (CENTRAL, May 2019). Five studies which compared the ACB with the PIA methods were included in our meta-analysis.

Results: Five studies containing 413 patients met the inclusion criteria. There were no significant differences between the ACB and the PIA group in visual analog scale (VAS) score at rest ($P = .14$) and movement ($P = .18$), quadriceps muscle strength ($P = .95$), complications ($P = .78$), length of stay (LOS) ($P = .54$), and time up and go (TUG) test ($P = .09$), While patients in the ACB group had less equivalent morphine consumption ($P < .05$) compared with the PIA group.

Conclusions: Our pooled data indicated the ACB group reduced the equivalent morphine consumption compared with the PIA group, with no statistically significant differences in the VAS score, quadriceps muscle strength, TUG test, complications, and LOS.

Abbreviations: ACB = adductor canal block, CIs = confidence intervals, DVT = deep vein thrombosis, FNB = femoral nerve block, LOS = length of hospital stay, MD = mean difference, PIA = periarticular infiltration analgesia, RCT = randomized controlled trial, TKA = total knee arthroplasty, TUG = time up and go, VAS = visual analog scale.

Keywords: adductor canal block, analgesia, meta-analysis, periarticular infiltration analgesia, total knee arthroplasty

1. Introduction

Total knee arthroplasty (TKA) is a successful procedure for end-stage osteoarthritis or rheumatoid arthritis.[1,2] TKA has been widely recognized as one of most important alternative surgery for patients to relief pain and improve functions. It was reported that the demand for primary TKA is expected to grow by 673% to 3.48 million in America when it comes to 2030 in the United States.[3] While postoperative pain following TKA is the most common problem which concerns surgeons.[4,5] Postoperative pain following TKA is an inevitable question which is known to affect patients' sleep and delay functional exercise and hospitalization days.[6,7]

Several techniques had been used for postoperative pain relief, such as intravenous opioids, peripheral nerve block, epidural analgesia, adductor block, femoral nerve block (FNB), and periarticular infiltration analgesia (PIA).[7–10] While it has been reported that implementing FNB with a risk of injuring the nerve, influencing quadriceps function, as well as benefiting the area of the femoral nerve only.[11] The PIA has been used over the last decade for postoperative analgesia following TKA. The PIA technique is the intraoperative method of local anesthetic, usually consist of 2 or more antalgic agents, such as nonsteroidal anti-inflammatory drugs, steroid hormones, local anesthetics of amide derivatives, and opioids.[12,13] The PIA has shown the analgesic effects in previous literatures, while the optimal infiltration technique and drugs remain controversial.[14] As well as the PIA method is limited to short-term postoperative analgesia.[12,15] Adductor canal block (ACB), an alternative form of peripheral nerve block, is increasingly being used.[16,17]

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Recently, some published studies have compared the efficacy between the ACB and the PIA methods, while they drew contradictory results from each other.[12–14,16,17]

Therefore, we conducted the meta-analysis of randomized controlled trials (RCTs) to compare the ACB and PIA methods in patients undergoing primary TKA.

The hypothesis of this meta-analysis was that the ACB is as good as the PIA for analgesia?

2. Method and materials

The study was approved by the ethics committee of the Xiaoshan Traditional Chinese Medical Hospital.

2.1. Search Strategy

We carefully searched PubMed (1996 to May 2019), Embase (1980 to May 2019), and Cochrane Library (CENTRAL, May 2019). We searched related references and Google Scholar meanwhile. Only RCTs were included in our studies. "Total knee arthroplasty," "Total knee replacement," "ACB," "PIA," "Adductor canal block," "Periarticular infiltration analgesia" were the keywords used with Boolean operators "AND" or "OR." Search results are shown in Figure 1.

2.2. Inclusion criteria

Trials were included in our meta-analysis if they met the patients, intervention, comparator, outcome, study design criteria.

(1) Patients: patients had received TKA for the first time.
(2) Intervention: the intervention was the application of ACB for TKA.
(3) Comparator: the comparator was PIA for TKA.
(4) Outcomes: equivalent morphine consumption, visual analog scale (VAS) at rest and movement, time up and go (TUG) test,

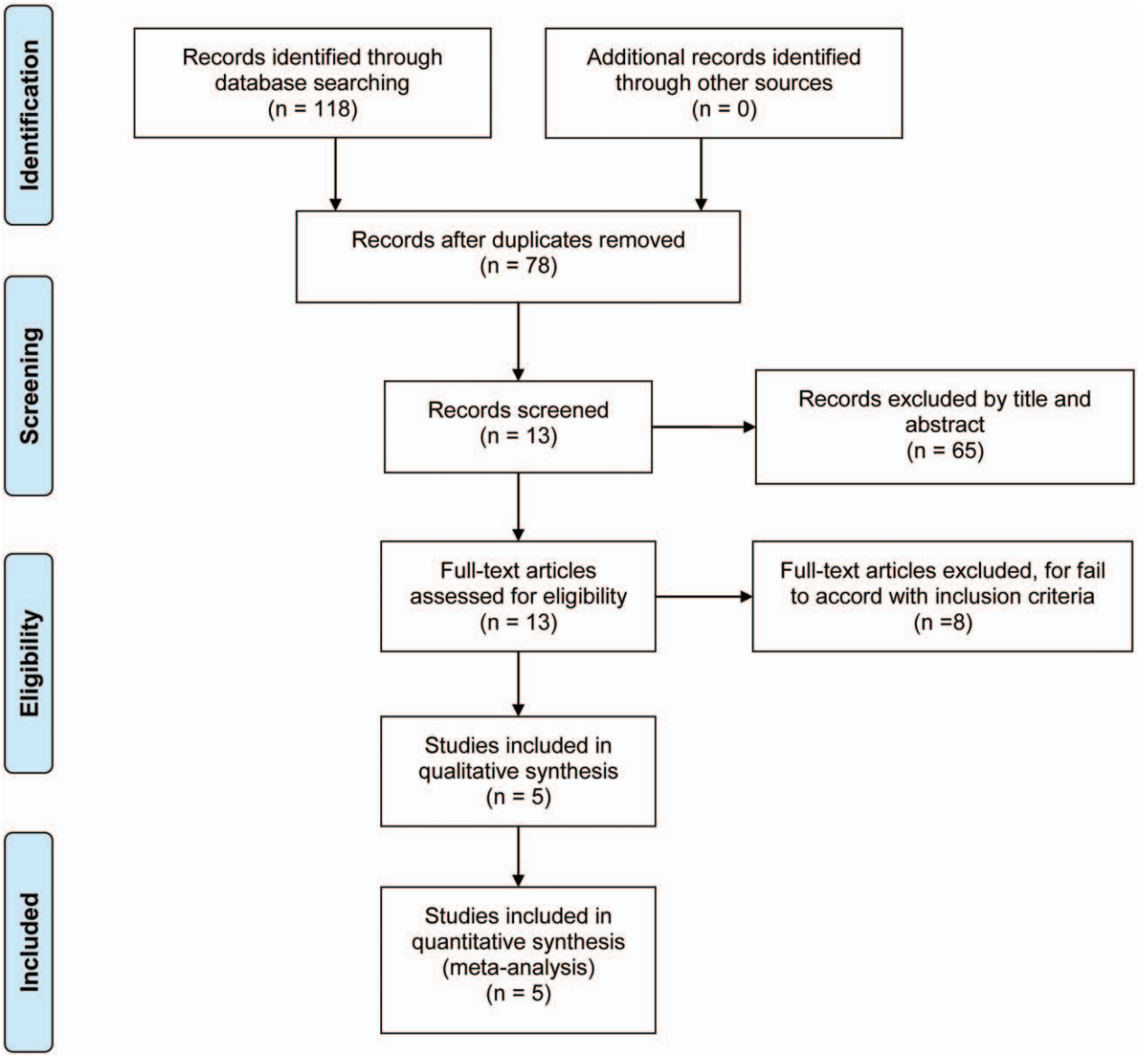


Figure 1. The search results and selection procedure.

Table 1

Conversion of analgesics use into equivalent morphine dosage.

Analgesics	Dosage of morphine equivalents (mg)
Morphine (subcutaneous or intramuscular)	10
Hydromorphone (subcutaneous or intramuscular/oral)	1.5/7.5
Codeine (subcutaneous or intramuscular/oral)	120/200
Oxycodone (oral)	20
Demerol (subcutaneous or intramuscular/oral)	80/300

quadriceps muscle strength, complications, and length of stay (LOS).

(5) Study design: RCTs.

2.3. Data extraction and bias risk assessment

Two researchers independently collected available data, and any disagreement between the 2 researches was judged by a third reviewer. Basic characteristics including patients, age, gender, body mass index, the American society of anesthesiologists, and reference type. The equivalent morphine consumption and VAS score were primary outcomes in our meta-analysis. To compare the opioids consumption, all opioids were converted to equivalent morphine consumption dosage according the standard formula (Table 1). The VAS sore consist of 11 pain level with o being no pain and 10 representing the worst pain. Secondary outcomes consisted of TUG test, quadriceps muscle strength, complications, and LOS. The Cochrane Handbook for systematic review of interventions (Review Manager 5.3) was used to evaluate the bias risk of included RCTs.

2.4. Statistical analysis

We used Review Manager Software 5.3 (Cochrane Collaboration, Copenhagen: The Nordic Cochrane Centre). For our meta-analysis. For continuous data, the mean differences (MD) with 95% confidence intervals (CIs) were applied to weigh the effect interval. As for uncontinuous data, the odds risk and the risk difference with 95% CIs were used to figure the effect interval. We used the value of P and I^2 to assess the statistical heterogeneity among included studies. When $I^2 < 50\%$ and $P > .1$ we applied a fixed-effects model, otherwise, a random-effect model was applied.

3. Results

3.1. Search results

According to search strategy, a total of 118 studies were retrieved, 40studies were excluded by Endnote software and 65 studies were removed by reading the title and abstract. Finally, 5 RCTs[12–14,16,17] were taken into our meta-analysis. The basic characteristics and interventions are summarized in Tables 2 and 3.

Table 2

The characteristics of included studies.

	ACB Group/PIA Group					
Studies, yr	Patients (n)	Ages, yr	Female Gender (%)	BMI	ASA (I/II/III/IV)	Reference Type
Tong et al 2018	20/20	64/68.5	60/70	28.5/27.8	0/11/9/0/13/7	RCT
Sogbein et al 2017	41/41	68/63	59/59	34.6/32.4	5/56/39/0/26/15	RCT
Gwam et al 2017	43/47	63/62	65/77	N/A	N/A	RCT
Sawhney et al 2016	51/54	66.4/67.6	60.8/66.7	33.9/36.7	N/A	RCT
Beausang et al 2016	50/46	64.7/68	N/A	30.6/30	N/A	RCT

ACB = adductor canal block, ASA = American society of anesthesiologists, N/A = not applicable, PIA = periarticular infiltration analgesia, RCT = randomized controlled trial.

Table 3

Characteristics of the included studies showing general intervention information.

	Analgesics and dosage				
Studies, yr	ACB group/PIA group		Surgical approach	Anesthesia	Pneumatic tourniquet
Tong et al 2018	30 mL of 0.5% Ropivacaine (150 mg)	Ropivacaine 150 mg, Ketorolac 30 mg, Morphine 10 mg, and adrenaline 200 mcg in a total volume of 75 mL	Standard surgical method	Spinal anesthesia	Use
Sogbein et al 2017	0.5% ropivacaine, 2.5 mg/mL of epinephrine, 10 mg of morphine, and 30 mg of ketorolac, for a total 60 mL.	100 mL of 0.3% ropivacaine, 2.5 mg/mL of epinephrine, 10 mg of morphine, and 30 mg of ketorolac.	N/A	Spinal anesthesia	N/A
Gwam et al 2017	10 mL of 0.25 to 0.5% bupivacaine, or 0.2 to 0.75% ropivacaine.	30 mL of 0.25% bupivacaine, with 1:200,000 parts epinephrine, 8 mg of dexamethasone, 2 mg of morphine, 30 mg of ketorolac, and 50 mL normal saline.	N/A	N/A	N/A
Sawhney et al 2016	30 mL of 0.5% ropivacaine.	300 mg ropivacaine, 10 mg morphine, 30 mg ketorolac, and 110 mL normal saline.	N/A	Peripheral nerve block and spinal anesthesia	N/A
Beausang et al 2016	0.2% ropivacaine at 10 cc/h for 48 h.	0.5% bupivacaine for 48 h.	Medial parapatellar approach	Spinal anesthesia	N/A

ACB = adductor canal block, cc = cubic centimeter, N/A = not applicable, PIA = periarticular infiltration analgesia.

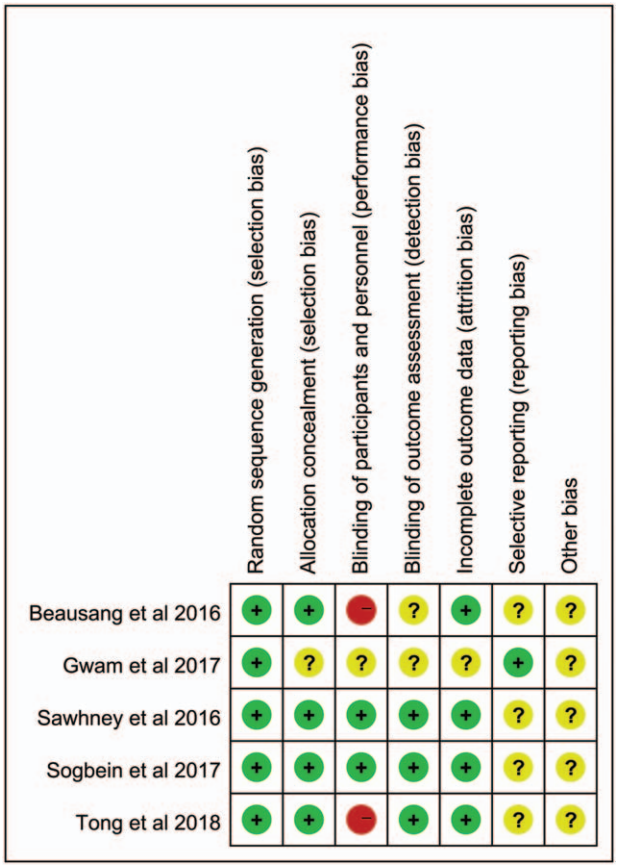


Figure 2. The risk of bias summary: review authors' judgement of each risk of bias items for each included studies.

3.2. Risk of bias of assessment

Risk of bias of assessment of RCTs is presented in Figures 2 and 3. Among the 5 RCTs, 3 RCTs[12,14,16] recoded using computer-generated randomization or web-based computerized block randomization service. Two RCTs[12,14] described allocation concealment via sealed envelopes or other methods. A double-blind method was applied in 2 studies.[12,16] The publications bias was assessed by the funnel plot diagram (Fig. 4). The symmetrical funnel plot diagram indicated that there were no significant risks of publications bias of equivalent morphine consumption, VAS score, complications, and LOS. Due to 2 studies in TUG test and quadriceps muscle strength, we were unable to conclude the risk of publication bias.

3.3. Results of meta-analysis

3.3.1. Meta-analysis of equivalent morphine consumption. Three studies[12,13,17] including 206 patients reported equivalent morphine consumption for postoperative day (POD) 1, compared with the PIA group, the ACB group reduced equivalent morphine consumption (MD = −7.20; 95% CI, [−14.18, −0.23]; $P < .05$; Fig. 5). Data from 5 studies[12–14,16,17] including 391 patients compared equivalent morphine consumption for POD 2, and the ACB group reduced equivalent morphine consumption (MD = −4.68; 95% CI, [−9.23, −0.13]; $P < .05$; Fig. 5). The total equivalent morphine consumption was reported in 2 studies[13,16] containing 185 patients. No significant differences were found between the ACB and the PIA groups (MD = 4.26; 95% CI, [−10.61, 19.14]; $P = .57$; Fig. 5). Our pooled data showed that compared with the PIA group, the ACB group reduced equivalent morphine consumption significantly (MD = −4.85; 95% CI, [−8.16, −1.55]; $P < .05$; Fig. 5). Due to significant heterogeneity in equivalent morphine consumption for day 1 ($x^2 = 44.16$; df = 2; $P < .01$; $I^2 = 95\%$; Fig. 5), and day 2 ($x^2 = 38.60$; df = 4; $P < .01$; $I^2 = 90\%$; Fig. 5), a random-effects model was applied.

3.3.2. Meta-analysis of visual analog scale at rest. One study[12] containing 70 patients reported VAS scores at rest at postoperative 12 hours, and no significant differences were found between the 2 groups (MD = 0.11; 95% CI, [−0.39, 0.61]; $P = .66$; Fig. 6). Data from 4 studies[12,13,16,17] including 359 patients compared the VAS scores at rest at postoperative 24 hours. No significant differences were found between the 2 groups (MD = 0.20; 95% CI, [−0.65, 1.05]; $P = .65$; Fig. 6). The VAS scores at rest at postoperative 48 hours were reported in 2 studies[12,16] containing 165 patients. The ACB group had significantly higher scores compared with the PIA group (MD = 0.45; 95% CI, [0.16,

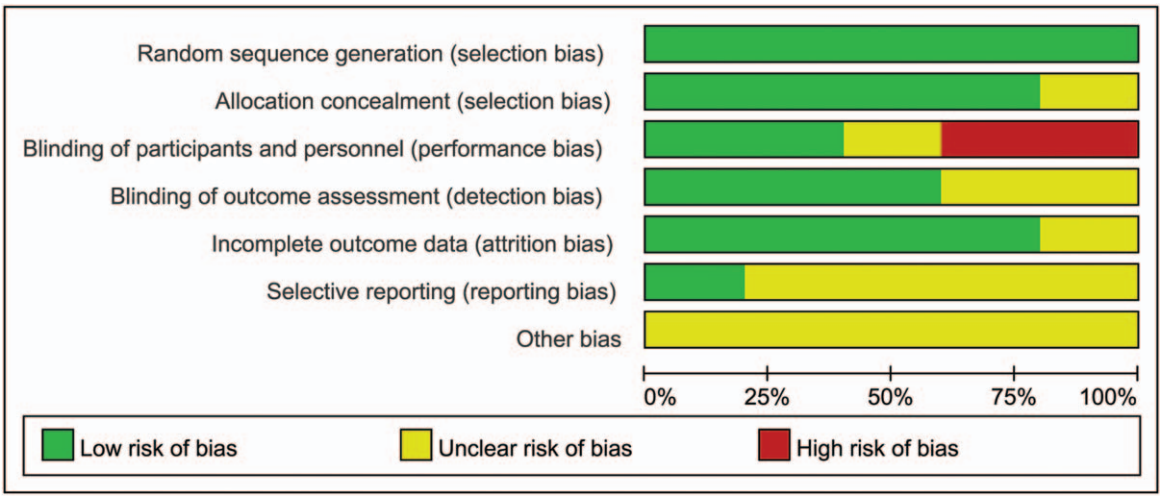


Figure 3. The risk of bias graph of the included studies.

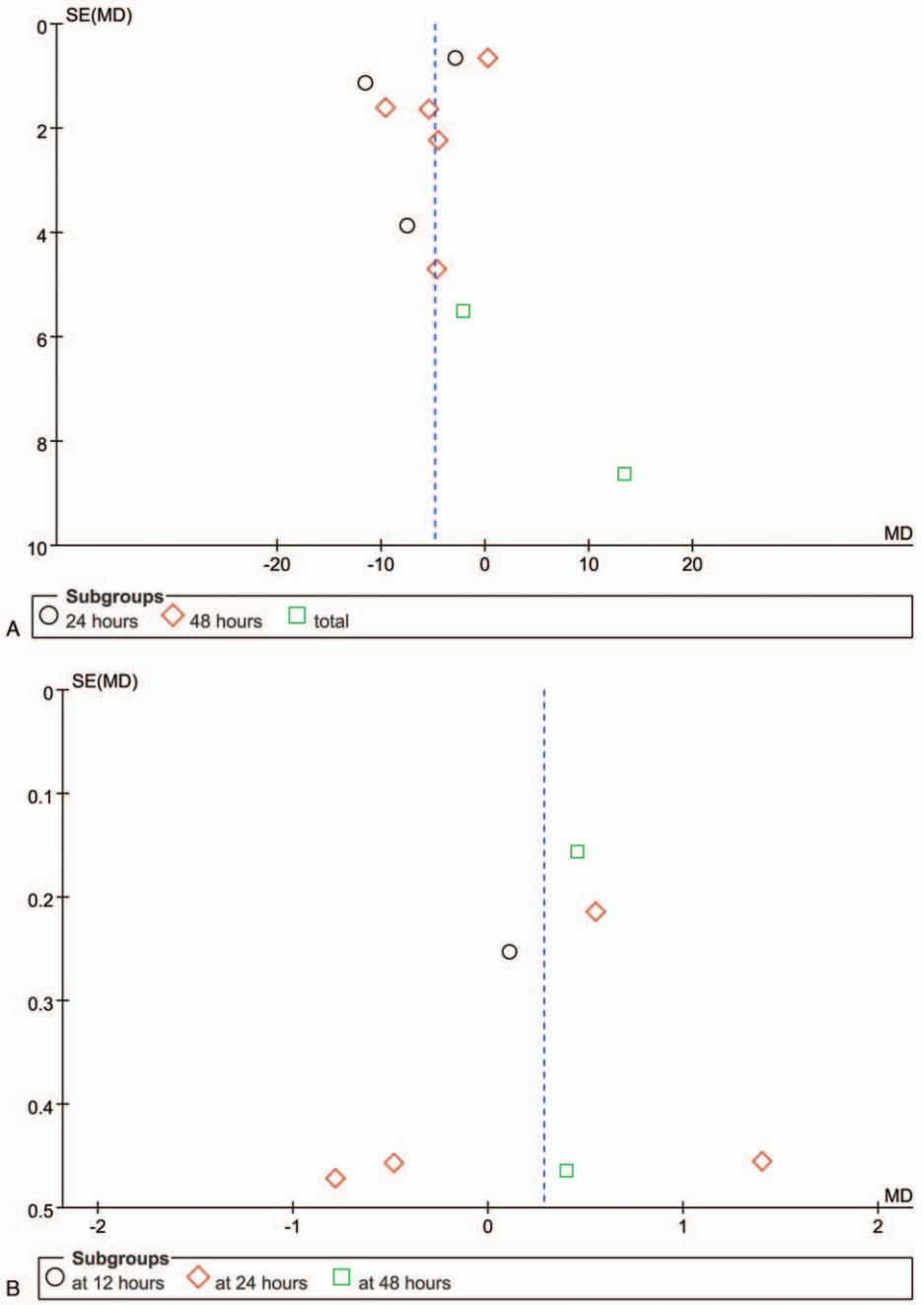


Figure 4. (A) A funnel plot of equivalent morphine consumption; (B) A funnel plot of VAS at rest; (C) A funnel plot of VAS at movement; (D) A funnel plot of timed up and go test; (E) A funnel plot of quadriceps muscle strength; (F) A funnel plot of Complications; (G) A funnel plot of LOS. LOS = length of stay, VAS = visual analog scale.

0.74]; $P < .05$; Fig. 6). Due to significant heterogeneity in VAS scores at rest at postoperative 24 hours ($x^2 = 15.24$; df = 3; $P < .01$; $I^2 = 80\%$; Fig. 6), a random-effects model was applied.

3.3.3. Meta-analysis of visual analog scale at movement. Sogbein et al[12] reported VAS scores at movement at postoperative 12 hours, and no significant differences were found between the 2 groups (MD = 0.20; 95% CI, [−0.27, 0.67]; $P = .40$; Fig. 7). Three studies[12,14,16] containing 203 patients reported the VAS scores at movement at postoperative 24 hours, while we were unable to find any significant differences between the 2 groups (MD = 0.90; 95% CI, [−0.84, 2.64]; $P = .31$; Fig. 7). Similar findings were found at postoperative 48 hours (MD = 0.30; 95% CI, [−1.11, 1.71]; $P = .68$; Fig. 7). We used a random-effects model because of the significant heterogeneity in VAS scores at movement at postoperative 24 hours ($x^2 = 45.91$; df = 2; $P < .01$; $I^2 = 96\%$; Fig. 7) and 48 hours ($x^2 = 34.28$; df = 2; $P < .01$; $I^2 = 94\%$; Fig. 7).

3.3.4. Meta-analysis of TUG test. TUG test was recorded in 2 studies[12,14] containing 110 patients. No significant differences were found between 2 groups (MD = 8.31; 95% CI, [−1.43,

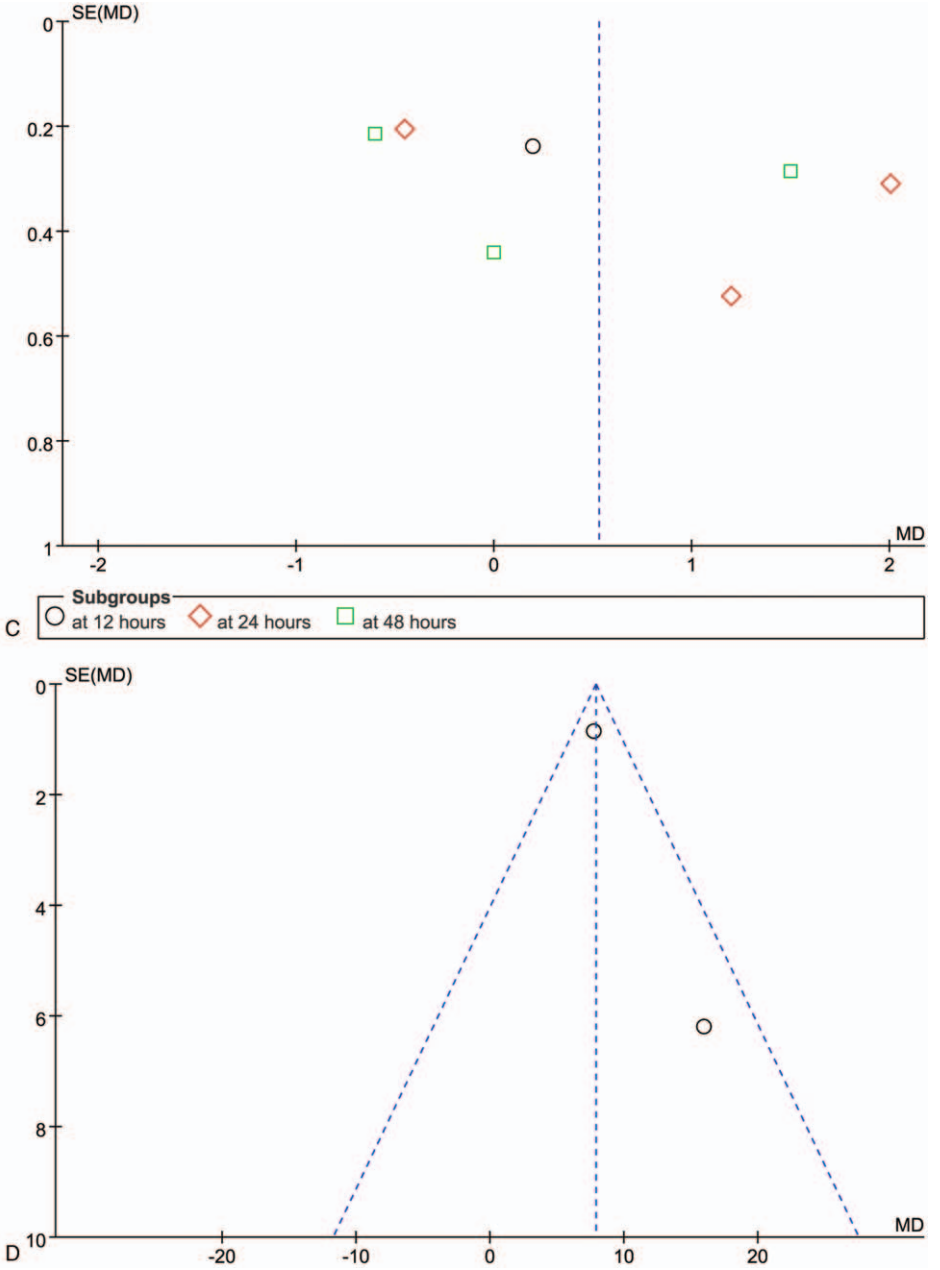


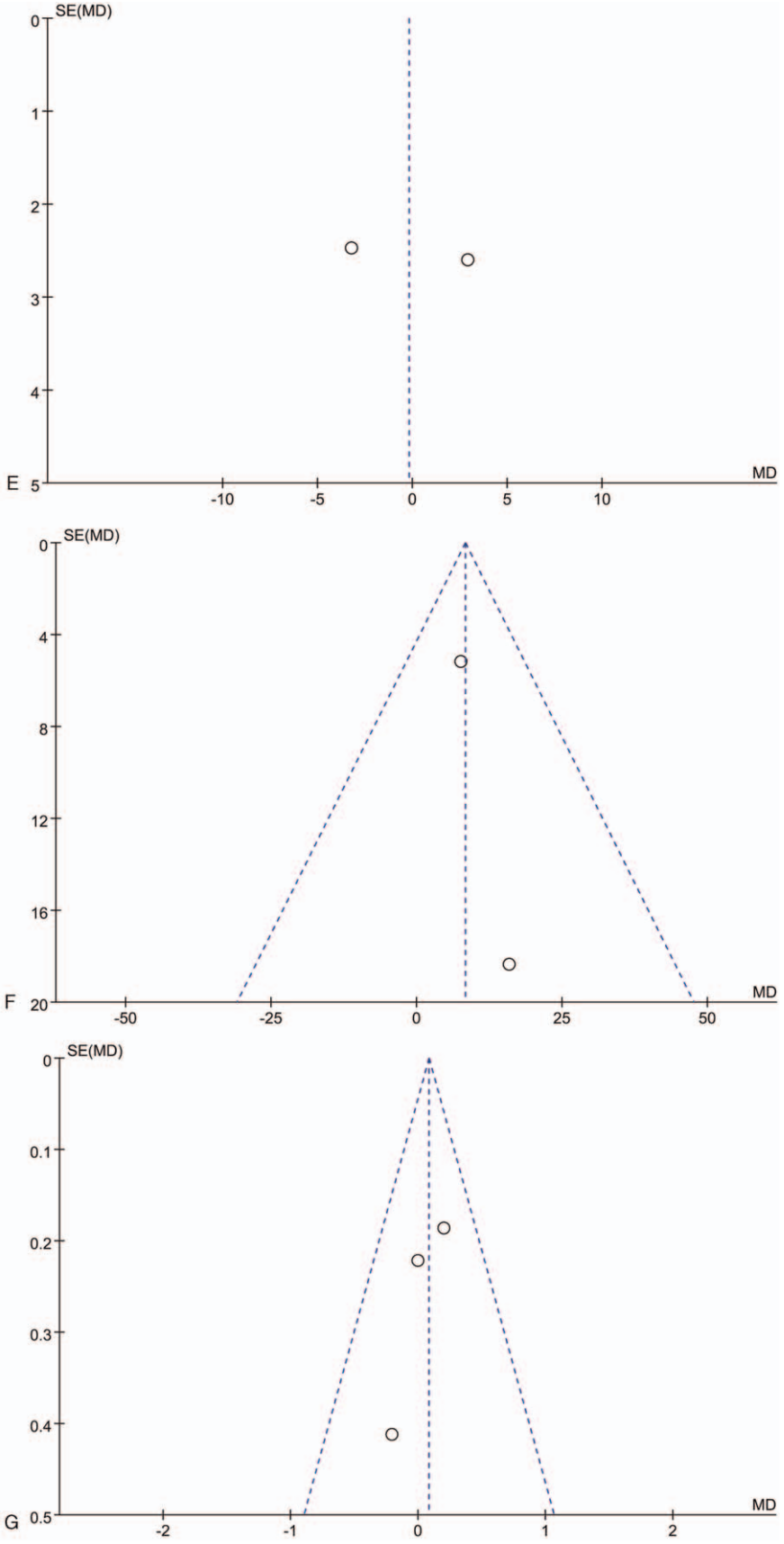
Figure 4. (Continued).

18.05]; $P=.09$; Fig. 8). We used a fixed-effect model for no heterogeneity were found between the PIA and the ACB group ($x^2=0.19$; df=1; $P=.66$; $I^2=0\%$; Fig. 8).

3.3.5. Meta-analysis of quadriceps muscle strength. Two studies[12,14] including 110 patients reported the quadriceps muscle strength postoperatively, and no significant differences were found between the 2 groups (MD=−0.20; 95% CI, [−6.18, 5.77]; $P=.95$; Fig. 9). We used a random-effects model for heterogeneity between studies ($x^2=12.18$; df=1; $P<.05$; $I^2=65\%$; Fig. 9).

3.3.6. Meta-analysis of complications. Tong et al[14] reported postoperative nausea and vomiting (PONV) in the ACB and PIA groups, and no significant differences were found between the groups (MD=0; 95% CI, [−0.30, 0.30]; $P=1$; Fig. 10). Data from 3 studies[12,16,17] including 261 patients reported the incidence of deep venous thrombosis (DVT) during hospital stay. No significant differences were found between the 2 groups (MD=0.01; 95% CI, [−0.02, 0.04]; $P=.61$; Fig. 10). We used a fixed-effects model, because no significant heterogeneity was found in DVT ($x^2=0.57$; df=2; $P=.75$; $I^2=0\%$; Fig. 10).

3.3.7. Meta-analysis of LOS. The LOS was reported in 3 studies[12–14] with a total of 200 patients. Pooled data



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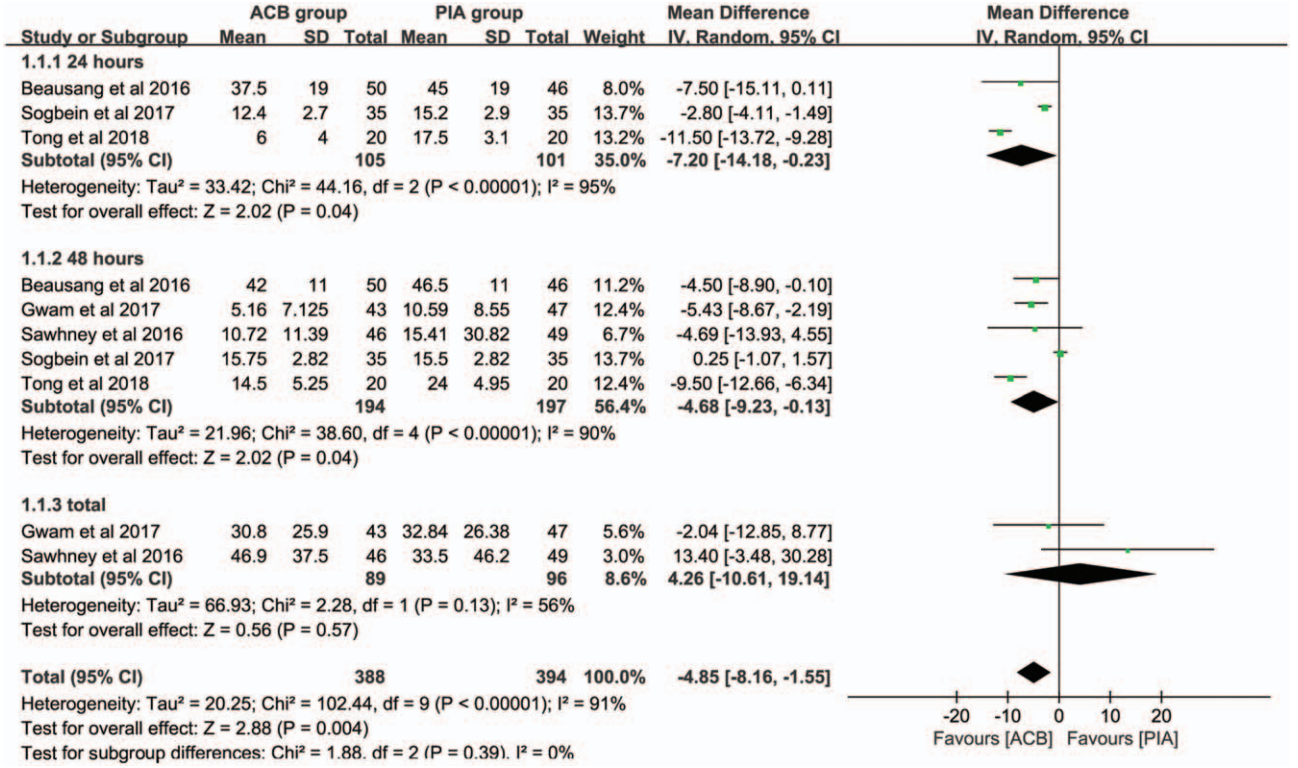

Figure 5. A forest plot diagram showing the equivalent morphine consumption (mg).

indicated that the ACB group had similar LOS compared with the PIA group (MD = 0.08; 95% CI, [−0.18, 0.35]; $P = .54$; Fig. 11). We used fixed-effects model due to the low heterogeneity ($x^2 = 1.01$; df = 2; $P = .60$; $I^2 = 0\%$; Fig. 11).

4. Discussion

The most important finding of our meta-analysis was that the ACB group reduced equivalent morphine consumption compared with the PIA group. And there were no statistically

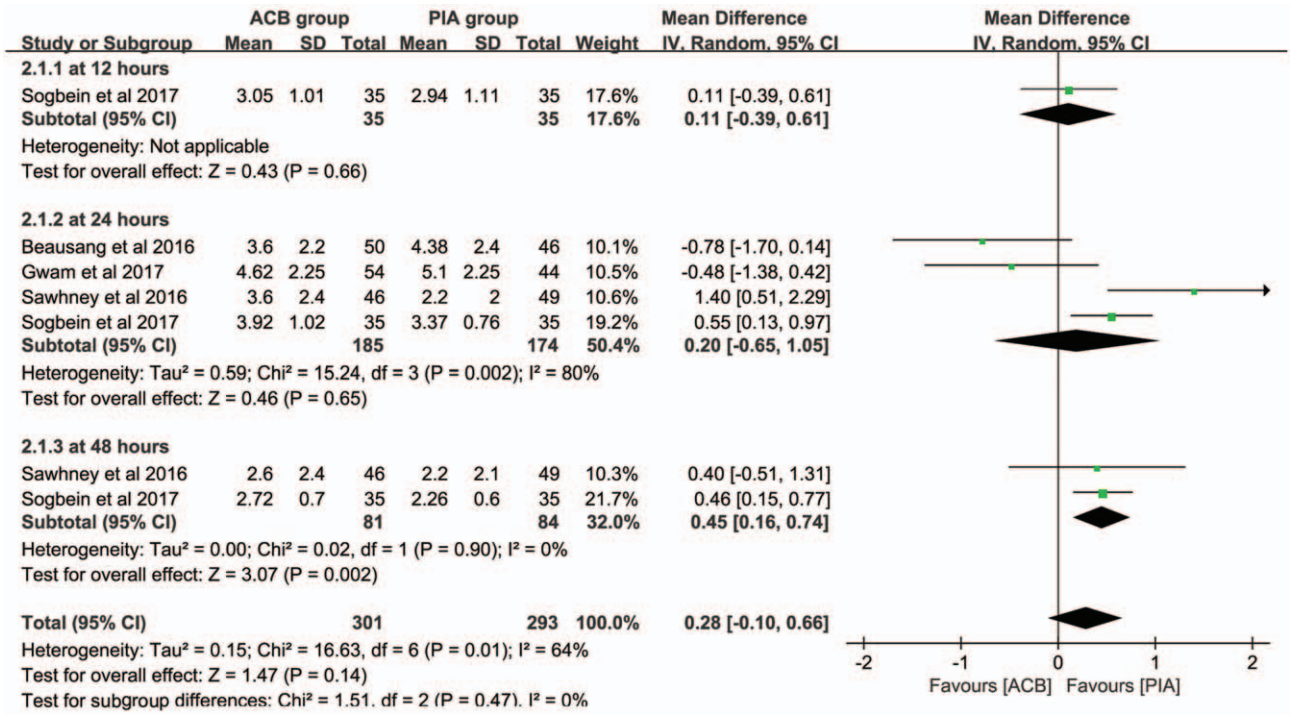

Figure 6. A forest plot diagram showing the VAS at rest. VAS = visual analog scale.

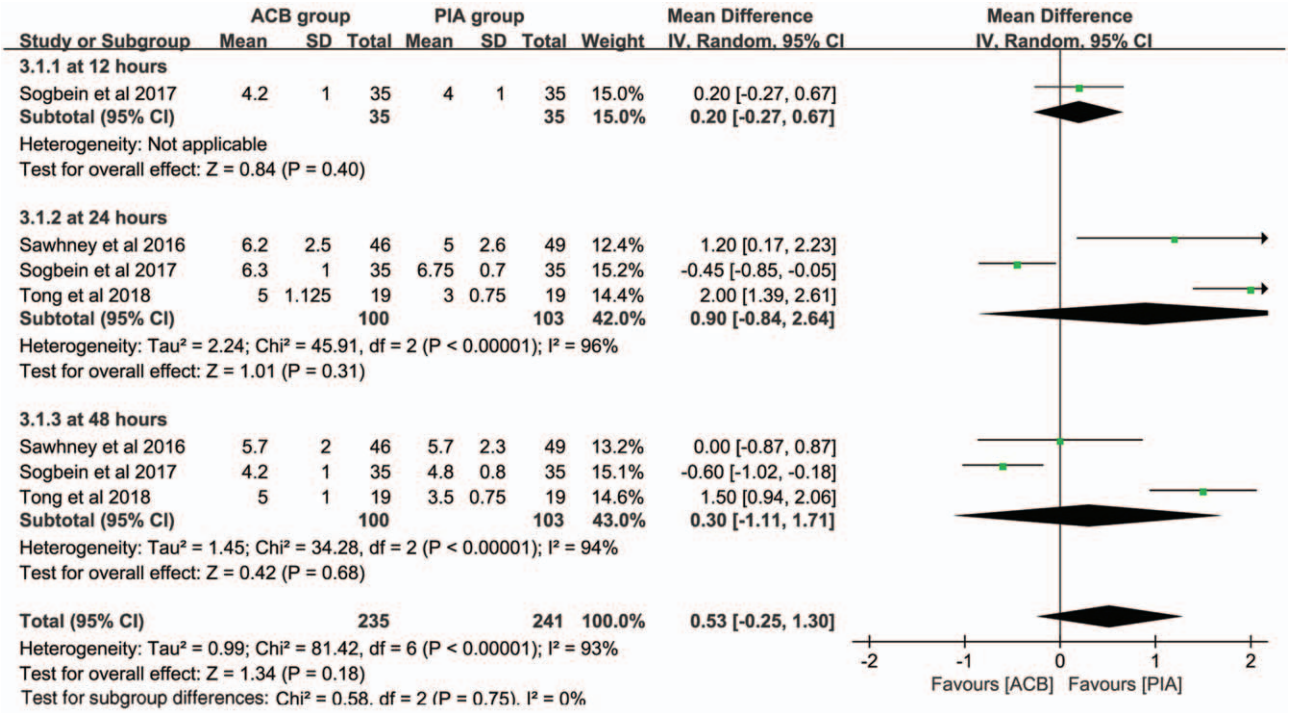

Figure 7. A forest plot diagram showing the VAS at movement. VAS = visual analog scale.

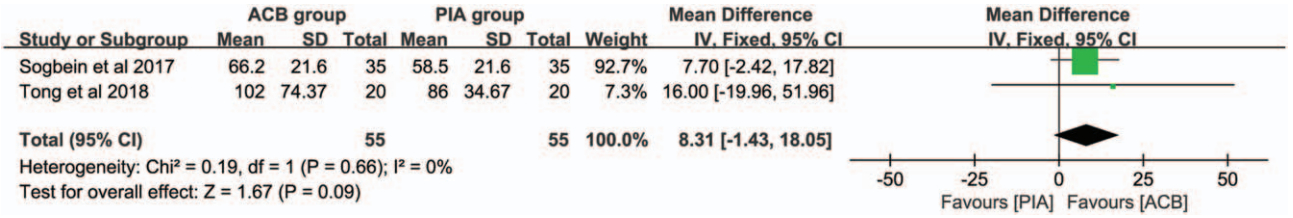

Figure 8. A forest plot diagram showing the timed up and go test (s).

differences in VAS score, quadriceps muscle strength, TUG test, complications, and LOS.

Appropriate pain management following TKA can lower postoperative pain, reduce LOS, and improve patients' satisfaction.[18] Postoperative pain is usually managed with the PIA, peripheral nerve block, and FNB.[19–21] FNBs has been successfully used for analgesia following TKA widely. Alternatives to FNBs, including epidural analgesia, PIA, and ACB, have been commonly for analgesia. Our previous studies have reported that PIA has similar analgesic properties to FNBs, without a risk of injuring the femoral nerve and quadriceps strength.[22] Recently, some published studies have reported that the ACB has similar analgesic properties as compared with the PIA method.[12,14]

The equivalent morphine consumption was the primary outcome in our meta-analysis. Morphine consumption was one of most indexes estimating the efficacy of analgesia methods. An RCT conducted by Sogbein et al[12] has reported that the ACB group had less oxycodone consumption on POD 1 and 2 compared to the PIA group. Tong et al[14] also has reported that

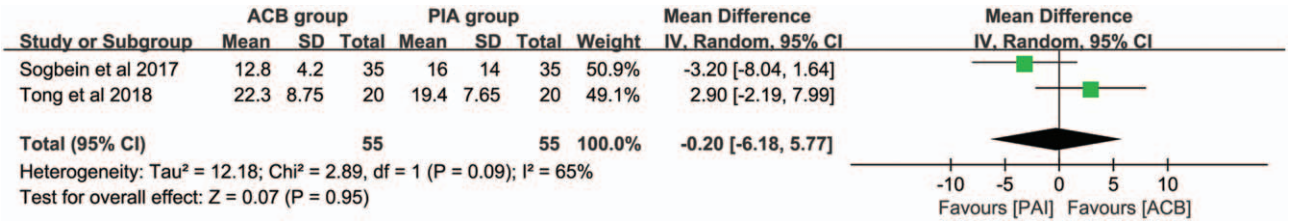

Figure 9. A forest plot diagram showing the quadriceps muscle strength.

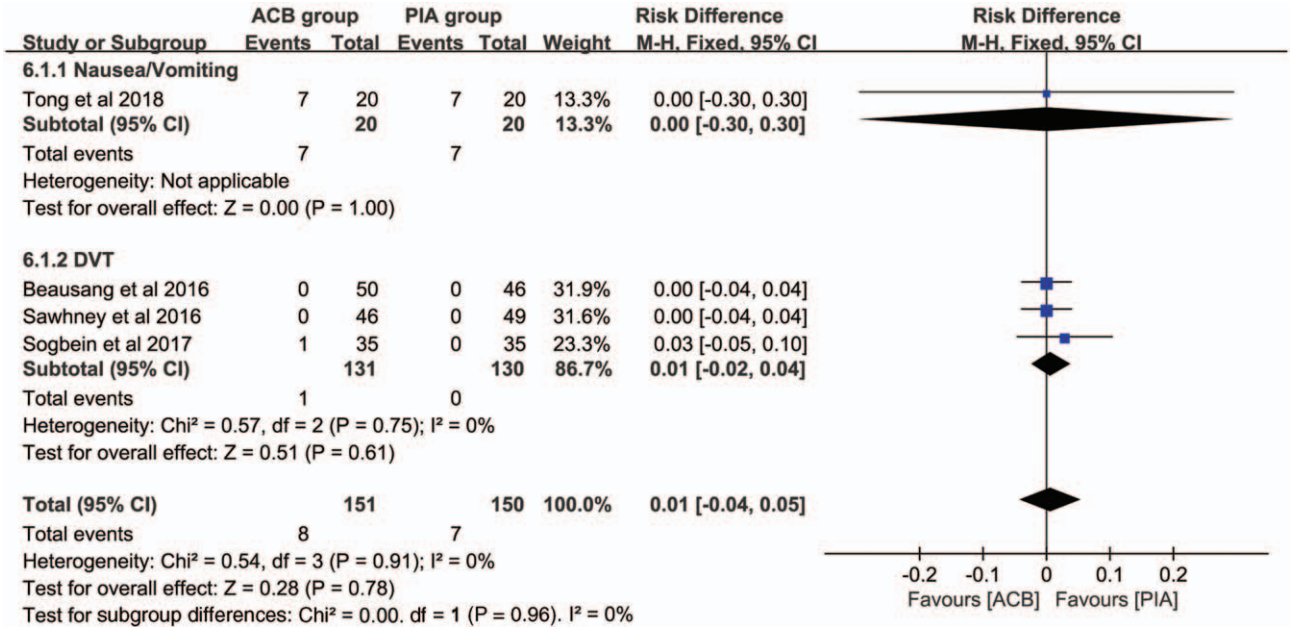

Figure 10. A forest plot diagram showing the complications.

the median morphine consumption on POD 1 was 6 mg (2.3–18.3) in the ACB group and 17.5 mg (12–24.3) in the PIA group, $P < .05$. Similarly, the morphine consumption on POD 2 was 14.5 mg (7.5–28.5) in the ACB group with 24 mg (14–33.8) in the PIA group, $P < .05$. Similar findings were also shown in Gwam et al study.[13] Our meta-analysis results also found that the ACB group had lower equivalent morphine consumption compared with the PIA group. Thus, we draw a conclusion that the ACB group had less morphine consumption compared to the PIA group.

The VAS score was used to weigh the analgesia effect. Recently, published studies[13,17] indicated that the ACB group has similar effects on pain relief compared with the PIA group. In the study of Sogbein et al,[12] they found that the ACB to be associated with better pain scores activity at 2 and 4 hours postoperatively and during rest at 2 hours following TKA. Beausang et al[17] demonstrated that the ACB provided significantly better pain control on POD 1 ($P < .05$) compared with the PIA, meanwhile a reduction in oxycodone consumption in the ACB group was noted compared with the PIA group. Similar findings were reported by Gwam et al.[13] Our pooled data also found that the ACB group had similar VAS score at rest when compared to the PIA group at POD 12 hours ($P = .66$) and 24 hours ($P = .65$), as well as at movement at POD 12 hours ($P = .40$), 24 hours ($P = .31$), and 48 hours ($P = .68$). Taking these results into consideration, we concluded that the ACB group provided equal analgesic effects in patients receiving TKA compared with the PIA group. However, it should be taken into consideration that heterogeneity existed between included studies.

The TUG test measures, in seconds, the time taken by an individual to stand up from a standard arm chair (approximate seat height of 46 cm, arm height 65 cm), walk a distance of 3 m (approximately 10 feet), turn, walk back to the chair, and sit down, was used to assess postoperative recovery. Sogbein et al[12] reported that there was no difference between the 2 groups with respect to TUG test. Tong et al[14] also indicated both the ACB and the PIA groups took same time to complete the TUG test without any statistically differences. Our pooled data also indicated that no significant differences were found between the ACB and the PIA groups.

Quadriceps strength is important to postoperative rehabilitation training. Several published studies have shown that patients who applied an ACB or PIA remained more quadriceps strength than patients used FNB method.[9] In the meta-analysis, our pooled data found that the ACB and the PIA groups retained similar quadriceps strength postoperatively, and the length of hospital stay between the 2 groups also showed no significant differences.

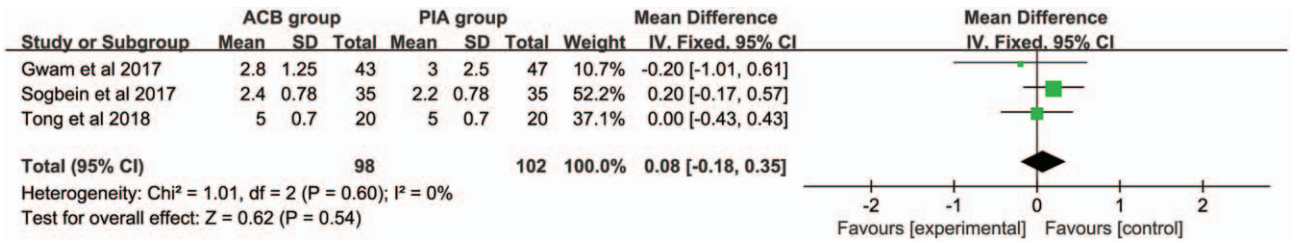

Figure 11. A forest plot diagram showing the LOS. LOS = length of stay.

We also compared the most common known risks of PONV and DVT. We failed to find any significant differences between the ACB and the PIA groups. Therefore, we make a conclusion that ACB analgesia has similar effects for patients undergoing TKA when compared to the PIA.

There were several limitations in our meta-analysis:

(1) Only 5 RCTs in our meta-analysis. The results would be more reliable if more high quality of RCTs were included.
(2) Different dosage and administration time of analgesics may create potential bias.
(3) With regard to the heterogeneity of equivalent morphine consumption at POD 24 hours ($I^2 = 95\%$) and POD 48 hours ($I^2 = 90\%$), we tried to find the source of heterogeneity. When we did not include the RCT of Sogbein et al,[12] the heterogeneity of equivalent morphine consumption at POD 24 hours (95% CI, [−13.32, −9.06]; $I^2 = 0\%$) and 48 hours (95% CI, [−9.22, −3.94]; $I^2 = 37\%$) reduced significantly. Thus we thought the study of Sogbein et al[12] was the sources of the heterogeneity. In the study of Sogbein et al,[12] they used a variety of analgesic drugs (0.5% ropivacaine, 2.5 mg/mL of epinephrine, 10 mg of morphine, and 30 mg of ketorolac) for ACB group. While other studies applied 0.5% ropivacaine only. Hence, the category of analgesia may be a cause of heterogeneity.
(4) The paper by Sawhney used peripheral nerve block with spinal anesthesia which might cause substantial bias. Finally, the preferred reporting items for systematic review and meta-analyses guidelines and Cochrane Handbook[23] were used in our meta-analysis to ensure our results reliable and actual.

5. Conclusion

In conclusion, we found the ACB method included in our meta-analysis were superior in terms of equivalent morphine consumption in the first 24 hours and 48 hours, without increasing the risk of complications, when compared to the PIA method. Thus, we conclude that the ACB is a feasible analgesic method for patients undergoing TKA.

Author contributions

Conceptualization: Lu-Kai Zhang.
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Formal analysis: Lu-Kai Zhang, Fang-Bing Zhu, Jun-Sheng Liu.
Funding acquisition: Lu-Kai Zhang, Fang-Bing Zhu, Zhi-Jin Zhang.
Investigation: Lu-Kai Zhang, Zhi-Jin Zhang.
Methodology: Lu-Kai Zhang.
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