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Efficacy of adductor canal block in total knee arthroplasty: a systematic review

D. F. Hoogma (*), S. Rex (**), M. Van de Velde (**) and S. Coppens (*)

Summary : Total knee arthroplasty (TKA) is associated with significant postoperative pain, frequently impairing recovery and delaying discharge from the hospital. Adductor canal block (ACB) could enhance postoperative recovery. This systematic review highlights that the evidence for ACB use in TKA is sparse. ACB is associated with adequate analgesia. Although evidence suggests that ambulation ability with an ACB is better preserved as compared to placebo, it remains unclear as compared to a femoral nerve block.

Keywords : Anesthesia, Conduction ; Arthroplasties, Replacement, Knee ; Nerve block.

Introduction

Total knee arthroplasty (TKA) is associated with moderate to severe postoperative pain, delaying early mobilization and prolonging hospital length of stay (LOS) (1). Postoperative analgesia aims at facilitating early mobilization and rehabilitation, thereby enhancing recovery and minimizing postoperative morbidity. A major challenge is to provide sufficient analgesia while preserving muscle function and strength. While central neuraxial blocks have been traditionally used for perioperative anesthesia and analgesia in TKA (2), the advances in ultrasound-guided regional anesthesia have made peripheral nerve blocks (PNB) increasingly popular (3).

The femoral nerve block (FNB) causes quadriceps muscle weakness and can therefore cause functional impairment, thereby potentially increasing the risk of postoperative falls (4). However, a recent large retrospective review found no association between peripheral nerve blocks and in-hospital falls (5). In contrast, the adductor canal block (ACB) is predominantly a sensory block, with the theoretical advantage of preserving quadriceps muscle strength and therefore promoting ambulation ability to a greater extent than FNB (6). In recent years, ACB has gained increasing popularity for knee surgery, despite limited evidence for its efficacy and efficiency. Two studies compared the quadriceps muscle strength in healthy volunteers after FNB or ACB and found that FNB decreased quadriceps muscle strength by 48-89%, as compared to only 5-8% for ACB (7, 8).

Recently, a meta-analysis comparing ACB to FNB has concluded that ACB is superior to FNB regarding pain control and ambulation ability (9). This meta-analysis has however been heavily criticized for methodological issues (10). To overcome these limitations, we performed a systematic review of the available literature, in order to assess whether ACB for primary TKA is effective during the postoperative in terms of morphine consumption, muscle strength, ambulation ability, and hospital LOS.

Materials and Methods

The authors performed a systematic review according to the instructions of the Cochrane handbook for systematic reviews of interventional studies (11) and the PRISMA guidelines (12). On October 6th, 2016, we conducted a literature search in the following databases: US National Library of Medicine database (MEDLINE), Excerpta Medica database (EMBASE), Scopus and Trip (without any date limitation). We used the following keywords in all four databases: (total knee arthroplasty AND saphenous nerve block) OR (total knee replacement

Danny Feike Hoogma, Steffen Rex, Marc Van de Velde, Steve Coppens
(*) Department of Anesthesiology, University Hospitals Leuven, Belgium.
(**) Departments of Cardiovascular Sciences, KU Leuven, and Department of Anesthesiology, University Hospitals Leuven, Belgium.
Correspondence address : Dr. Danny Hoogma, Department of Anesthesiology, University Hospitals Leuven, Herestraat 49, 3000 Leuven, Belgium. Tel. +32 16 34 42 70. Fax +32 16 34 42 45
E-mail : Danny.hoogma@uzleuven.be
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AND saphenous nerve block) OR (total knee replacement AND adductor canal block) OR (total knee arthroplasty AND adductor canal block)). We included only randomized controlled trials (RCTs). The protocol has been registered in the PROSPERO register: CRD42016036149.

Each abstract was then screened to identify studies in which patients were randomized to receive either ACB or other analgesic techniques for primary TKA. In addition, the references of these RCTs were searched for any relevant articles not identified in our primary search. The specific outcomes sought in each article were morphine consumption, quadriceps muscle strength and hospital LOS.

We excluded studies if surgery was other than primary TKA. Moreover, studies were excluded if the PNB was administered as rescue therapy. The flowchart of the literature search is illustrated in Figure 1.

A self-designed form for extraction of the trial characteristics and the aforementioned outcomes was used to assist in data collection. Data extracted for analysis included author, number of patients, study design, additional analgesia, systemic opioid equivalents, quadriceps muscle strength, gait aids used during ambulation ability testing, hospital LOS, and the primary outcome parameter of each study.

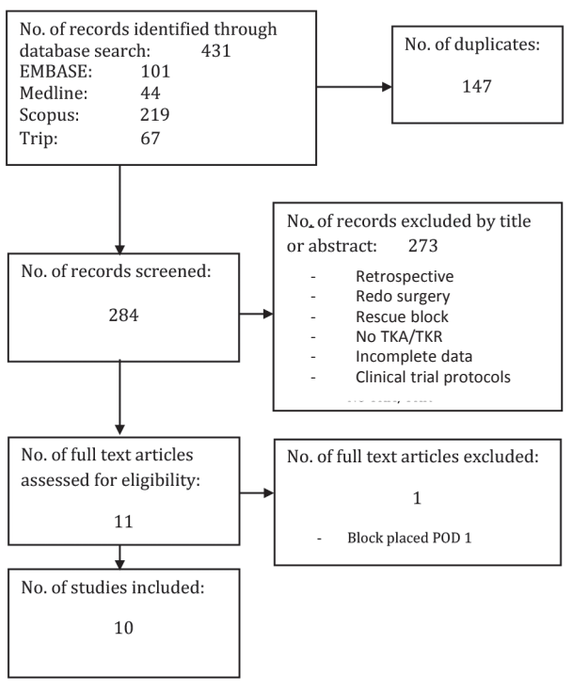

Fig. 1. — Flow diagram of the study selection (last updated October 2016)

The Jadad scale, also known as the Oxford quality scoring system, was used to assess the methodological quality of randomization, blinding, and withdrawal of the included studies (Table 1) (13).

Results

Study selection and characteristics

The literature search yielded a total of 431 citations. After excluding duplicates and non-pertinent titles or abstracts, only 11 citations were eligible. The large number of duplicates was due to a considerable overlap between the databases. Moreover, a large number of clinical trial protocols was found in one database. One prospective, randomized study was retrieved from the search, insofar as, in this study, the ACB was placed only on the first postoperative day (POD) (Fig. 1).

Hence, ten studies could be included in our analysis (Table 1), with two studies analyzing single shot ACB and 8 studies testing continuous/intermittent ACB (CACB). In 6 studies, ACB was compared with FNB (6, 14-18), while in 2 studies the control group received placebo injections in the adductor canal (19, 20). One study used a sham catheter as control intervention (21) and the last one compared single shot ACB to CACB (22).

Quality

Quality assessment for randomization, blinding, and withdrawal was performed using the Jadad scale (13). This yielded 8 studies with a maximum score of 5/5 and 2 studies with a score of 3/5 due to inadequate blinding. Primary and secondary outcome measures were clearly defined in 9 out of 10 studies (Table 1).

Opioid consumption

Opioid consumption was recorded in 8 out of 10 studies, but only in 3 studies as primary outcome (Table 1, 2). Due to different control groups and adjuvant analgesia techniques, the results were not entirely uniform.

Testing ACB against placebo in the control group resulted in a significant difference in total morphine consumption (20). The comparison of ACB with a sham-block resulted in a reduced IV morphine equivalent consumption at 48 h in the group with ACB. After adjustment for baseline covariates, reduced morphine consumption was still in favor of ACB (21).

Table 1:

Detailed information on study features. CACB, continuous adductor canal block; ASIS, anterior superior iliac spine; CFNB, continuous femoral nerve block; POD, postoperative day; NRS, numerical rating scale; ACB, adductor canal block; FNB, femoral nerve block; SSACB, single shot adductor canal block; TUG, timed up and go; MIA, multi-site infiltration analgesia

Author	Number of patients	Study groups	Jadad score	Primary outcome
Jenstrup (20)	75	CACB (halfway between ASIS and patella) with initial bolus of 30 ml ropivacaine 0.75% and intermittent boluses (15 ml/6 h) ropivacaine 0.75% compared to placebo, until 18 h postoperative. 24 h postoperative 15 ml bolus ropivacaine 0.75% in both groups.	5	Morphine consumption
Andersen (19)	40	CACB (halfway between base patella and ASIS) with initial bolus of 15 ml ropivacaine 0.75% and intermittent boluses (15 ml/12 h) ropivacaine 0.75% compared to placebo, until POD 2: 8pm.	5	Worst pain on movement
Jaeger (6)	54	CACB (halfway between ASIS and patella) compared to CFNB Bolus of 30 ml ropivacaine 0.5% followed by an infusion ropivacaine 0.2% 8 ml/h during 24 h. Sham-catheter on the other puncture site.	5	Maximum voluntary isometric contraction of the quadriceps
Hanson (21)	80	CACB (halfway between inguinal crease and patella) 8 ml/h ropivacaine 0.2% compared to sham catheter, until POD 2.	5	Morphine consumption
Kim (14)	94	ACB (distal third of the thigh) bupivacaine 0.5% 15 ml compared to FNB bupivacaine 0.25% 30 ml.	5	Not clearly defined: dynamometer, numerical rating scale for pain (non-inferiority) and morphine consumption (non-inferiority)
Shah and Jain (15)	100	CACB (halfway between ASIS and patella) compared to CFNB Bolus of 30 ml ropivacaine 0.75% followed by intermittent boluses ropivacaine 0.25% 30 ml/4h, until POD 2: 8am.	3	Visual analog pain scale and mobilization ability
Wiesmann (16)	46	CACB (distal thigh) compared to CFNB Bolus of 15 ml ropivacaine 0.375% followed by an infusion ropivacaine 0.2% 6 ml/h, during 48h.	5	Mobilisation (TUG)
Shah (22)	90	CACB compared to SSACB (halfway between ASIS and patella) Bolus of 30 ml ropivacaine 0.75%, followed with intermittent boluses ropivacaine 0.25% 30 ml/4 h compared to placebo, until POD 2: 8am.	5	Visual analog pain scale
Machi (17)	84	CACB (midpoint between ASIS and cephalad margin of the patella) compared to CFNB Bolus of 30 ml lidocaine 2% followed by an infusion ropivacaine 0.2% 6 ml/h with boluses 4 ml/30min, during 72 h.	3	Time to attain 4 discharge criteria (adequate analgesia; intravenous opioid independence; ability to stand, walk 3 m, return, and sit down; and ambulate 30 m)
Li (18)	90	MIA compared to FNB and/or ACB (middle or distal thigh level) FNB and ACB: Bolus of 20 ml ropivacaine 0.5% with epinephrine 0.1 mg. MIA: 70 ml ropivacaine 0.25% with epinephrine 0.3 mg	5	Numerical rating score (NRS) at rest and with activity and change of vital signs

When comparing ACB to FNB, cumulative total morphine consumption 6-8, 24 and 48 hours postoperatively was comparable between groups. ACB was therefore described as not being inferior to FNB (6,14,18). In two other studies, there was no difference in systemic opioid equivalent requirements, even up to 72 h after surgery, although the FNB group reported superior analgesia during physical therapy (16, 17).

Adding an AC with ropivacaine to a single dose local infiltration analgesia (LIA) resulted in a reduced total morphine IV equivalents consumption on the day of surgery, when compared to LIA alone. This difference disappeared on the third postoperative day (19). Opioid consumption was even higher in the group with ACB as compared to multi-site infiltration analgesia (MIA), which is a combination of 3 local infiltrations sites, intra- and peri-articular with wound infiltration (18).

Muscle strength and ambulation

Muscle strength was evaluated in 9 out of 10 studies by analyzing the maximum voluntary isometric contraction using dynamometry or the "Timed Up-and-Go" (TUG) test as parameter for ambulation (Table 2). Three studies analyzed muscle strength as the primary outcome parameter (6,14,16), while the remaining 6 studies assessed muscle strength as a secondary outcome (15,17,18, 20-22).

Single shot ACB was found to be non-inferior to FNB with respect to absolute force of the quadriceps muscle. This effect was even superior for strength with significantly higher median dynamometer readings at 6-8 h postoperatively with non superior pain scores during physical therapy in the ACB group. Dynamometer readings were however not superior at 12 h, 24 h and 48 h (14, 18). Another RCT found that patients with CACB had significantly higher quadriceps strength as compared to patients with continuous FNB (CFNB) at 24 h postoperatively (6).

The comparison of CACB with a sham catheter showed stronger absolute quadriceps force on the second postoperative day but not on the first postoperative day. Pain scores during these physical therapy sessions were significantly lower in the CACB group (21).

Seven studies reported TUG as the ambulation parameter. In two studies, there was no difference between CACB and CFNB regarding the TUG test and pain scores (6, 16). Also, CACB compared to single shot ACB showed no significant difference in TUG testing 24 hours postoperatively (22). This was also true in another study comparing ACB to FNB (18). In contrast, one RCT found a significant difference in favour of patients receiving CACB with ropivacaine when compared to placebo at 24 h postoperatively (20). Others found CACB to be superior with respect to the TUG test when compared to CFNB (15). Likewise, Machi and colleagues detected a significant difference in ambulation ability in favor of CACB, with 97% of the patients being able to fulfill the TUG test 24 h postoperatively, as compared to 56% in the CFNB group. Patients of the latter group had significantly less pain during physical therapy (17).

Hospital length of stay

Hospital LOS was recorded in 6 out of 10 studies (Table 2). In 5 studies, it was recorded as a secondary outcome. Only one RCT reported a decrease in hospital LOS for the CACB group when compared to CFNB (15). Four RCT's reported that hospital LOS was not different for the two groups when comparing CACB to placebo, CACB to single shot ACB, CACB to CFNB, or ACB to FNB. There were no difference in the incidence of adverse effects (14, 18, 19, 22).

One study defined the time until achievement of 4 discharge criteria as the primary outcome: adequate analgesia, independence from IV opioids, ability to stand, walk 3 m, return, and sit down, and ambulate 30 m. Patients with a CACB reached all four criteria within a median time of 55 h as compared to 61 h for those with a CFNB. This difference did not reach statistical significance (17).

Discussion

Effective treatment of postoperative pain and enhancing early rehabilitation is important to facilitate early discharge from the hospital (23). The ACB is apparently associated with adequate analgesia and with maintenance of quadriceps strength. Whether the effects contribute to enhanced ambulation ability, or a reduction in hospital LOS remains uncertain.

TKA is associated with moderate to severe postoperative pain, for which most often multimodal systemic analgesia is used. Postoperative morphine consumption is one of the most frequently used surrogate markers for the relatively objective assessment of postoperative pain (24). Eight out of 10 studies included in our systematic review reported the postoperative use of opioids, with only 2 studies showing a reduction in morphine

Table 2.

Studies comparing morphine consumption, quadriceps muscle strength, ambulation ability and hospital length of stay as outcome parameter. CACB, continuous adductor canal block; PCA, patient controlled analgesia; LIA, local infiltration analgesia; CFNB, continuous femoral nerve block; SD, standard deviation; FNB, femoral nerve block; ACB, adductor canal block; CSE, combined spinal epidural anesthesia; MIA, mutli-site infiltration analgesia; CI, confidence interval; TUG, timed up and go; POD, postoperative day; MVIC, maximum voluntary isometric contraction; CSE, combined spinal epidural anesthesia; IQR, interquartile range; SSACB, single shot adductor canal block; PACU, postanesthesia care unit, SR, sustained release.

Author	Study groups	Additional analgesia	Morphine consumption (mg)	Quadriceps muscle strength	Hospital length of stay (LOS)
Jenstrup (20)	CACB compared to placebo	Spinal anesthesia (10 mg hyperbaric bupivacaine) Morphine-PCA Acetaminophen 1g/6 h orally Ibuprofen 400 mg/6 h orally	40 ± 21 *vs* 56 ± 26 (Mean ± SD, P = 0.006) at 24h	TUG 36 ± 17 *vs* 50 ± 29 s (Mean ± SD) at 24h 33 ± 20 *vs* 41 ± 27 s (Mean ± SD) at 26h	na
Andersen (19)	CACB compared to placebo	Spinal anesthesia (12.5-15 mg hyperbaric bupivacaine) LIA (100 ml ropivacaine 2 mg/ ml + epinephrine 10 μg/ ml) Morphine-PCA Acetaminophen 1g q 6 h orally Morphine ER 10 mg q 12 h orally	67 (22-159) *vs* 68 (20-163) (Median + range) on the 3th POD	na	3.1 (2.4-5) *vs* 3.1 (1.8-5.2) days (Median, range) P = 0.68
Jaeger (6)	CACB compared to CFNB	Spinal anesthesia (10-15 mg hyperbaric bupivacaine) Morphine-PCA Acetaminophen 1g q 6 h orally Ibuprofen 400 mg q 6 h orally	22 ± 9 *vs* 22 ± 21 (Mean ± SD) P = 0.94) at 24 h	MVIC at 24 h postoperatively (% of baseline value): 52 (9-92) *vs* 18 (0-69) % (Median, 95% CI), P = 0.004 TUG at 24 h postoperatively 37 ± 22 *vs* 39 ± 16 s (Mean ± SD)	na
Hanson (21)	CACB compared to placebo	Orally Acetaminophen 975 mg, celecoxib 400 mg and gabapentin 900 mg Sedation with 0-250 μg fentanyl and 0-5 mg midazolam IV FNB with ropivacaine 0.5% 20 ml + epinephrine 1/40.000 Spinal anesthesia (12.5 mg plain bupivacaine) Varied practice: LIA (30 ml bupivacaine 0.25% + morphine 10 mg) Morphine-PCA	46.7 (95% CI, 34.86-58.5) *vs* 63.4 (95% CI, 51.89-74.83) (Least-square mean) at 48 h	Quadriceps strength (maximum pounds of force) (Mean ± SD) POD1: 24.9 ± 20.5 *vs* 23.3 ± 20.1, P = 0.746 POD2: 34.3 ± 25.3 *vs* 21.2 ± 17, P = 0.01	na
Kim (14)	ACB compared to FNB	Meloxicam 7.5 mg or 15 mg orally preoperatively CSE (spinal anesthesia 12.5 mg hyperbaric bupivacaine, epidural top-ups with lidocaine 2%) Epidural-PCA Oxycodone/acetaminophen 5/325 mg q 4 h orally as needed Meloxicam 7.5 mg/d or 15 mg/d orally	6-8 h: 36.5 ± 17,9 *vs* 35.8 ± 20.7 (Mean ± SD) 24 h: 50.3 ± 30.8 *vs* 50.4 ± 33.1 (Mean ± SD)	Dynamometer readings (Mean ± SD) 6-8h: 7.3 ± 5.4 *vs* 2.2 ± 3.8 (kilogram-force unit) 24h: 3.9 ± 4.2 *vs* 4.0 ± 4.0 (kilogram-force unit) No difference of the non-operatively leg at any given time	3.7 ± 0.8 *vs* 3.6 ± 0.8 days (Mean ± SD) P = 0.73

Author	Study groups	Additional analgesia	Morphine consumption (mg)	Quadriceps muscle strength	Hospital length of stay (LOS)
Shah and Jain (15)	CACB compared to CFNB	Spinal anesthesia (12.5 mg hyperbaric bupivacaine) Intra-articular infiltration (20 ml 0,25 bupivacaine + 250 mg cefuroxime + 40 mg triamcinolone acetonide) Diclofenac sodium 75 mg q 8 h IV or paracetamol 1000 mg q 8 h IV Acetaminophen 500 mg q 6 h orally Tramadol 50 mg IV (rescue)	na	TUG at 24h postoperatively 51.81 ± 7.93 *vs* 180 ± 68.4 s (Mean ± SD)	3.08 ± 0.4 *vs* 3.92 ± 0.44 days (Mean ± SD) P < 0.001
Wiesmann (16)	CACB compared to CFNB	General anesthesia Anterior sciatic nerve block Ibuprofen 400-600 mg q 8 h orally Piritramide IV 3.75-7.5 mg (rescue)	Intraoperative fentanyl (mg) median (25^{th}-75^{th} IQR): 0.4 (0.25-0.5) *vs* 0.4 (0.4-0.5). P = 0.11 PACU piritramide median (25^{th}-75^{th} IQR): 1.0 (0-7.5) *vs* 0.0 (0-7.5). P = 0.74	TUG median (25^{th}-75^{th} IQR): POD 2: 45 (35-80) *vs* 64.5 (56-91) s POD 3: 51 (37-65) *vs* 45 (37-70) s	na
Shah (22)	CACB compared to SSACB	Spinal anesthesia (15 mg hyperbaric bupivacaine) Intra-articular infiltration (20 ml 0.5 bupivacaine + 250 mg cefuroxime + 40 mg triamcinolone acetonide) Diclofenac sodium 75 mg q 8 h IV or paracetamol 1000 mg q 8 h IV Acetaminophen 500 mg q 6 h orally Tramadol 50 mg IV (rescue)	na	TUG at 24h postoperatively (Mean ± SD) 57.95 ± 8.46 *vs* 60.3 ± 3.82 s	3.08 ± 0.35 *vs* 3.2 ± 0.4 days (Mean ± SD) P = 0.157
Machi (17)	CACB compared to CFNB	Spinal anesthesia (10-15 mg hyperbaric bupivacaine) or general anesthesia) LIA (30 ml ropivacaine 0.5%, epinephrine 10 µg/ml, ketolorac 30 mg and tranexamic acid 2g) Lidocaine 2% 10 ml perineural or SR oxycodone 5-10 mg orally on PACU if needed Acetaminophen 975 mg q 6h orally Celecoxib 200 mg q 12 h orally SR oxycodone 10 mg q 12 h orall	Similar intravenous opioid requirements	TUG (% of treatment group) POD1 morning: 79 *vs* 31% POD1 afternoon: 100 *vs* 65%	Discharge readiness criteria as median (25^{th}-75^{th} IQR) POD1: 55 (42-63) *vs* 61 (49-69) h Hospital LOS as median (25^{th}-75^{th} IQR): 74 (69-76) *vs* 73 (70-77) h. P = 0.97
Li (18)	MIA compared to FNB and ACB	Celecoxib 200 mg q 12 h orally 3 days preoperative Diclofenac 50 mg q 12 h orally SR oxycodone 10 mg q 12 h orally Parecoxib q 12 h intramuscular Pethidine 50 mg intramuscular on PACU if needed	Opioid consumption (Mean ± SD): MIA: 32.5 ± 21.7 FNB: 38.3 ± 22.6 ACB: 37.9 ± 20.6 P < 0.05	TUG POD 1 and 2: ACB = FNB, P > 0.05	Postoperative hospital days (mean ± SD): MIA: 3.6 ± 0.8 FNB: 5.2 ± 1.0 ACB: 4.9 ± 0.8 P < 0.05

consumption for the ACB, but only when compared to placebo (20,21). The other 6 studies showed no benefit of the ACB as compared to the respective control group (Table 2).

It is difficult to draw valid conclusions from these data as, concomitant analgesia protocols varied widely in each individual study. Moreover, the studies lack a uniform control group, making quantification and comparison of the effects nearly impossible. As least common denominator, the studies suggest that ACB decreases opioid requirements when compared to placebo. When added to LIA, it is equipotent when compared to FNB, but might be inferior to MIA.

Nine out of 10 studies reported muscle strength and/or ambulation ability, albeit using different outcome parameters. All studies assessing muscle strength found ACB to be superior to the control group (6,14,21). When assessing ambulation ability with a TUG test, three studies found ACB to be superior to the control group (15,17,20) while four other studies showed no benefit of ACB as compared to the control group (6,16,18,22). Compared to placebo, an ACB seems to enhance ambulation, possibly due to lower pain scores (19-21).

Again, the unambiguous interpretation of these results is difficult, as endpoints were not unifor mly assessed. Every single trial used a different method to study ambulation ability. Data suggest that ACB preserves muscle strength better than the comparators. This is especially true in volunteer studies (8). Whether this translates into better ambulation ability in a postoperative setting, where surgery and the use of a tourniquet also causes quadriceps dysfunction, has still to be unequivocally demonstrated.

A total of 6 studies report hospital LOS with only 1 study finding ACB to be superior to the control group (15) and 1 study showing that ACB is inferior to MIA in that respect (18). The remaining 4 studies found ACB to be equivalent to the control group (14,19,22). Of note, the only study that was specifically powered for the assessment of LOS did not find any differences for this outcome parameter (17). Besides, the other studies fail to report discharge criteria making a definitive conclusion impossible.

We acknowledge that our systematic review suffers from several limitations. First, variability in the control groups, the use of different application techniques (continuous infusion, single shot, or repeated bolus administration), and varying concentrations/volumes of local anesthetic agents render a reliable evaluation of the analgesic and motoric effects highly vulnerable to bias. Second, the limited number of RCTs, their non-homogenous designs, and a lack of uniform outcome parameters also precluded a statistical meta-analysis of the aggregated data. Third, the studies included in our review had sample sizes varying from 40 to 100 patients. As a consequence, the studies clearly lacked power to detect differences in most of the secondary outcome parameters (25).

Forth, the individual studies included in our systematic review suffer from a lack in consensus regarding the exact anatomical location of the adductor canal (Table 1). A recent meta-analysis from Hussain et al. also highlights this limiting factor, suggesting a better definition of its anatomical location (26). Some authors recommend to use a subsartorial approach with blockade of the vastus medialis branches of the femoral nerve, together with the saphenous nerve (27). Others have suggested that the real ACB is located in the Hunters canal, beneath the vastoadductor membrane, hence much lower than the position that can be reached by the mid-thigh approach (28). It has been brought forward that only at this location, there is dispersion of the injectate into the popliteal fossa (29). However, the efficacy of ACB close to the hiatus may result in a lower success rate when compared to the more traditional subsartorial mid-thigh ACB (27, 30).

In conclusion, the use of ACB in TKA is apparently associated with adequate analgesia and maintenance of quadriceps strength, without conclusive evidence of enhanced ambulation ability. The data show a trend toward ACB being superior as compared to placebo and at least non-inferior as compared to FNB. Based on the heterogeneity of the available data, it is impossible to exactly quantify these effects. Further adequately powered clinical trials with uniform outcome parameters and definitions are warranted.

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