Evidence Basis for Regional Anesthesia in Ambulatory Arthroscopic Knee Surgery and Anterior Cruciate Ligament Reconstruction: Part II: Adductor Canal Nerve Block—A Systematic Review and Meta-analysis

Herman Sehmbi, MD, EDRA, EDAIC,*† Richard Brull, MD, FRCPC,‡§
Ushma Jitendra Shah, DA, DNB, EDRA, EDAIC, FRCA,‡‖ Kariem El-Boghdadly, FRCA,‡‖
David Nguyen, MD,¶ Girish P. Joshi, MBBS, MD, FFARCSI,# and Faraj W. Abdallah, MD‡**††‡‡

BACKGROUND: Adductor canal block (ACB) has emerged as an effective analgesic regional technique for major knee surgeries in the last decade. Its motor-sparing properties make it particularly attractive for ambulatory knee surgery, but evidence supporting its use in ambulatory arthroscopic knee surgery is conflicting. This systematic review and meta-analysis evaluates the analgesic effects of ACB for ambulatory arthroscopic knee surgeries.

METHODS: We conducted a comprehensive search of electronic databases for randomized controlled trials examining the analgesic effects of ACB compared to control or any other analgesic modality. Both minor arthroscopic and anterior cruciate ligament reconstruction (ACLR) surgeries were considered. Rest and dynamic pain scores, opioid consumption, opioid-related adverse effects, time to first analgesic request, patient satisfaction, quadriceps strength, and block-related complications were evaluated. Data were pooled using random-effects modeling.

RESULTS: Our search yielded 10 randomized controlled trials comparing ACB with placebo or femoral nerve block (FNB); these were subgrouped according to the type of knee surgery. For minor knee arthroscopic surgery, ACB provided reduced postoperative resting pain scores by a mean difference (95% confidence interval) of −1.46 cm (−2.03 to −0.90) ($P < .00001$), −0.51 cm (−0.92 to −0.10) ($P = .02$), and −0.48 cm (−0.93 to −0.04) ($P = .03$) at 0, 6, and 8 hours, respectively, compared to control. Dynamic pain scores were reduced by a mean difference (95% confidence interval) of −1.50 cm (−2.10 to −0.90) ($P < .00001$), −0.50 cm (−0.95 to −0.04) ($P = .03$), and −0.59 cm (−1.12 to −0.05) ($P = .03$) at 0, 6, and 8 hours, respectively, compared to control. ACB also reduced the cumulative 24-hour oral morphine equivalent consumption by −7.41 mg (−14.75 to −0.08) ($P = .05$) compared to control. For ACLR surgery, ACB did not provide any analgesic benefits and did not improve any of the examined outcomes, compared to control. ACB was also not different from FNB for these outcomes.

CONCLUSIONS: After minor ambulatory arthroscopic knee surgery, ACB provides modest analgesic benefits, including improved relief for rest pain, and reduced opioid consumption for up to 8 and 24 hours, respectively. The analgesic benefits of ACB are not different from placebo or FNB after ambulatory ACLR, suggesting a limited role of both blocks in this procedure. Paucity of trials dictates cautious interpretation of these findings. Future studies are needed to determine the role of ACB in the setting of local anesthetic instillation and/or graft donor-site analgesia. (Anesth Analg 2019;128:223–38)

KEY POINTS

- **Question:** Does adductor canal block improve analgesic outcomes for ambulatory arthroscopic knee surgeries?
- **Findings:** Administering adductor canal block to patients having simple knee arthroscopy results in minor improvements in pain scores (up to 8 hours) and analgesic consumption (up to 24 hours), but it does not improve analgesic outcomes after anterior cruciate ligament repair.
- **Meaning:** The analgesic role of adductor canal block in ambulatory arthroscopic knee surgery is limited.

From the *Department of Anesthesia, University of Western Ontario, London, Ontario, Canada; †Department of Anesthesia, London Health Science Centre, London, Ontario, Canada; ‡Department of Anesthesia, University of Toronto, Toronto, Ontario, Canada; §Department of Anesthesia, Women's College Hospital, Toronto, Ontario, Canada; ‖Department of Anesthesia, Toronto Western Hospital, Toronto, Ontario, Canada; ¶Department of Anesthesia, University of Calgary, Calgary, Alberta, Canada; #Department of Anesthesiology and Pain Management, University of Texas Southwestern Medical Center, Dallas, Texas; **Department of Anesthesia, Keenan Research Centre, Li Ka Shing Knowledge Institute, St Michael's Hospital, Toronto, Ontario, Canada; ††Department of Anesthesiology and Pain Medicine, University of Ottawa, Ontario, Canada; and the ‡‡ Ottawa Hospital Research Institute, University of Ottawa, Ontario, Canada.

The anterior cruciate ligament is 1 of the most commonly injured ligament of the knee.[1,2] Anterior cruciate ligament reconstruction (ACLR) is performed primarily on an ambulatory basis wherein effective postoperative analgesia is essential for patient satisfaction,[3] timely discharge,[4] and functional recovery.[5] Consensus regarding the optimal management of postoperative pain in this setting is currently lacking, with a wide variety of multimodal analgesia elements, including peripheral nerve blocks and local instillation analgesia (LIA), described in the literature.[3] Consequently, the question of whether all patients should receive peripheral nerve blocks and/or LIA to improve postoperative pain after ACLR remains unanswered. To inform the decision of practitioners providing care to this patient population, we undertook this research series to (1) systematically review the evidence, (2) evaluate the quality of this evidence, and (3) develop evidence-based practice guidelines regarding the incorporation of peripheral nerve blocks and/or LIA into the perioperative care of patients undergoing ACLR.

In part II of this series, we examine the evidence basis for using the adductor canal block (ACB) for analgesia after arthroscopic knee surgery, including ACLR. ACB[6] has gained popularity as an analgesic technique for knee arthroplasty[7,8] over the last 10 years. Compared to femoral nerve block (FNB), ACB offers effective analgesia while sparing motor function, thus facilitating early physiotherapy and ambulation after knee arthroplasty.[9–11] These advantages are particularly desirable in ambulatory arthroscopic knee surgery. By providing adequate pain control while preserving motor power, ACB can theoretically facilitate outpatient discharge[12] and protect against falls.[13,14] However, available evidence of the analgesic efficacy of ACB in the setting of arthroscopic knee surgery is conflicting, with some studies supporting its use,[15–19] while others indicating a lack of benefit.[20–23] This systematic review and meta-analysis seeks to evaluate the analgesic effects of ACB, compared to control or any other analgesic modality, for ambulatory arthroscopic knee surgeries.

METHODS

We followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses[24] recommendations during the preparation of this review. We reviewed and evaluated randomized controlled trials (RCTs) that compared ACB to either placebo or any other analgesic modality using a pre-designed protocol.

Literature Search

A comprehensive search of 10 databases, including the US National Library of Medicine database (MEDLINE), Medline In-Process, PubMed-NOT-Medline, Excerpta Medica database (Embase), Cochrane Central Controlled Trials Database Register, Cochrane Systematic Reviews Database, Biosys Previews, Web of Science, Scopus, and Cumulative Index to Nursing and Allied Health Literature (CINAHL), was performed by a librarian. These databases were searched using medical subject headings (MeSH), text words, and controlled vocabulary terms relating to the following: (1) ACB, (2) saphenous nerve block, (3) infrapatellar block, (4) anterior cruciate ligament repair, (5) knee surgery; (6) postoperative pain, and (7) analgesia. These search terms were used individually and in assorted permutations (Supplemental Digital Content, Appendix, http://links.lww.com/AA/C87). The search was limited to RCTs in humans, published in any language between 1946 and April 2017. Nonindexed articles were retrieved using Google Scholar; we also hand searched the bibliographies of retrieved manuscripts to identify additional relevant RCTs. The clinical trial registry (www.clinicaltrials.gov) was searched for any potentially relevant ongoing or completed but not yet published RCTs. Abstracts were excluded.

Eligibility Criteria

We sought full-text published manuscripts of RCTs using the "PICO" approach. We predefined the "Population" as adult in- or outpatients (≥18 years old) undergoing arthroscopic knee surgery, regardless of its nature; "Intervention" as single-shot ACB or saphenous nerve or infrapatellar nerve block; "Comparator" as a placebo or any other analgesic modality; and "Outcomes" as analgesic outcomes.

Studies were excluded if the (1) design was not an RCT (eg, case series, observational studies, conference proceedings, systematic reviews); (2) population was healthy volunteers or knee arthroplasty patients; (3) intervention included continuous ACB; (4) comparator was spinal anesthesia; and (5) analgesic outcomes were not assessed. Additionally, inclusion was restricted to studies of ambulatory patients (23-hour stay) where both study arms receive at least 2 components of multimodal analgesia, in addition to ACB, namely opioids, acetaminophen, nonsteroidal anti-inflammatory drugs, cyclooxygenase-2 inhibitors, N-methyl-D-aspartate receptor antagonists (ie, ketamine, magnesium), α-2 agonists (ie, clonidine and dexmedetomidine), anticonvulsants (gabapentin and pregabalin), glucocorticoids, β-blockers, or LIA.[25]

Study Selection

Two authors (H.S. and U.J.S.) evaluated the retrieved abstracts independently. The decision to include or exclude the qualifying studies was taken by consensus between these 2 authors, and the opinion of a third author (F.W.A.) was obtained in the case of disagreement.

Assessment of Bias

Two authors (H.S. and K.E.-B.) independently assessed the quality of included RCTs using the Cochrane Collaboration Risk of Bias tool for RCTs.[26] This quality appraisal tool evaluates RCTs for biases, including selection (random sequence generation and allocation concealment), performance (blinding of participants and personnel), detection (blinding of outcome assessors), attrition (incomplete outcome data), reporting (selective reporting), and other forms of bias. The authors assigned a score (low, unclear, or high risk of bias) to each type of bias RCT by consensus. If an agreement could not be reached, the third author (F.W.A.) was consulted. Studies were not excluded from the review based on "risk of bias" scoring.

Data Extraction

Two authors (H.S. and U.J.S.) independently extracted data from the included RCTs using a standardized data extraction form on Microsoft Excel Spreadsheet 2016 (Microsoft Corp, Redmond, WA). Extracted data included the study characteristics (name of the principal author, publication year, overall sample size, number of patients in each study arm, type of comparator, type of surgery performed, intraoperative anesthetic technique, and admission status), the block technique in the intervention arm (local anesthetic type, concentration and volume, use of additives, timing of block, site of injection, guidance technique for block localization, and performance of any supplementary nerve blocks), as well as the perioperative analgesic regimens used (preoperative, intraoperative, in postanesthetic care unit, in-hospital, and postdischarge). Any discrepancies in the extracted data were resolved by discussion. If consensus could still not be reached, a third author's opinion (F.W.A.) was sought.

Outcomes Assessed

Postoperative rest pain severity (visual analog scale [VAS]: 0 = no pain, 10 = worst pain) score at 6 hours after arthroscopic knee surgery was designated as the primary outcome. When reported as numerical rating scale scores, these were converted to VAS scores and used for reporting in this review.[27] A 1-point difference in pain scores is generally perceived as clinically important. We considered this time point as clinically relevant as it usually coincides with the patient's arrival at home. It also allows assessing the effect of single-injection ACB before it wears off, in isolation from intraoperative anesthetics and analgesics. Secondary outcomes included rest pain scores (at 0, 8, 12, and 24 hours) and dynamic pain scores (at 0, 6, 8, 12, and 24 hours). Cumulative 24-hour opioid consumption (oral morphine equivalents in milligram), opioid-related adverse effects such as postoperative nausea and vomiting, antiemetic use and postoperative sedation/drowsiness (defines as the inability to stay awake on a verbal rating scale), time to first analgesic request (defined as the time from arrival in postanesthesia care unit to the request for first analgesic), and patient satisfaction (on a VAS scale) were also assessed. In addition, we evaluated ACB success rate (as reported in individual studies), quadriceps strength (defined as mean maximal voluntary isometric contraction of 3 consecutive sustained knee extension maneuvers),[8] and any block-related complications.

Statistical Analysis

Data related to the above-mentioned outcomes were extracted from the tables or the text of the published manuscripts. Authors of respective manuscripts were contacted (e-mail) for raw data, addition data, and nonnumerical data where needed. If a response was not obtained, the required data were extracted from the published figures using online plot digitizer software (WebPlotDigitizer 3.9, 2015; Ankit Rohatgi, Austin, TX). In the case of a crossover design, the data from the study were extracted before the point of crossover and treated as a parallel study design.[28]

We recorded continuous data as mean and standard deviation (SD). These estimates (mean and SD) were derived using the method described by Hozo et al[29] when median and range were available and Wan et al[30] when median and interquartile range were available. When least mean square and error were provided, the mean was assumed to be equal to least mean square, while the SD was derived from the standard error using the method outlined in the Cochrane Handbook for Systematic Reviews of Interventions.[31] When pain was described as area under curve, time-specific pain scores were calculated by dividing the area under curve by the number of time unit used, while the SD was derived from the range (or 95% confidence interval [CI]).[31] If a single representative (mean) value of pain was provided for the 24-hour period, it was taken as representative of values at other preceding time points as well. In the case of missing SD, standard imputation techniques were used where appropriate.[32] Dichotomous data reporting of opioid-related adverse effects were converted to risk (n/N), with the highest frequency risk used to include data from patients who developed a given event at least once. When dichotomous data were required from continuous data, we attempted contacting the authors as a first resort before converting the data to dichotomous data as described by Moore et al.[33] All opioids were converted to oral morphine equivalent dose in milligrams using standard guidelines.[34,35] The grade of muscle power was converted into percentage strength[15] by assigning incremental percentage points to an increasing power grade score.

Meta-analysis

Extracted outcome data were imported into Review Manager software (RevMan 5.3; Cochrane Library, Oxford, England) by 1 author (H.S.) and checked for accuracy by another (F.W.A.). Continuous data (resting pain, dynamic pain, 24-hour oral morphine consumption) were statistically meta-analyzed using the inverse-variance method and represented as mean difference (MD) with 95% CI. Dichotomous data (risk of nausea/vomiting, sedation, and antiemetic use) were meta-analyzed using the Mantel–Haenszel method and represented as odds ratio with 95% CI. When the scales of measurement were different (patient satisfaction score), the data were represented using the MD and 95% CI. As numerous sources of clinical heterogeneity existed, such as surgical procedure, nature of comparator, block techniques, local anesthetic types and doses, and multimodal analgesic regimens used, random-effects modeling by DerSimonian and Laird[36] was used to pool data. We used an intention-to-treat approach by analyzing the data available from all participants in each study group, regardless of compliance or attrition, to estimate the influence on treatment effect. Differences were considered statistically significant when $P < .05$ (2-sided) and when 0 and 1 were not included in the 95% CI for continuous and dichotomous outcomes, respectively. Other outcomes such as success rate (of ACB) and postblock reduction in quadriceps strength were expressed as percentage points. Where applicable, the Bonferroni–Holm correction was used to adjust the threshold of statistical significance for repeated measurements. The analysis of secondary outcomes was considered exploratory, thus no further correction for type I error was performed. Finally, we evaluated the risk of publication bias

by checking for asymmetry of the Begg funnel plot and performing the Egger regression test.[37] To avoid overstating the results and inflating type I error, we used secondary outcome results for hypothesis generation.

Addressing Heterogeneity

We used the I^2 statistical method to identify statistical heterogeneity.[38] Some of the challenges in appraising evidence for arthroscopic knee surgery stem from the inclusion of both minor (eg, meniscectomy) and more complex (eg, ACLR) arthroscopic knee procedures in the same study. These 2 broad groups differ in the invasiveness of the surgical procedure, postoperative analgesic requirements, as well as functional recovery profiles. Thus, we hypothesized a priori that differences in surgical procedures and study comparator arms would result in significant heterogeneity and used subgroups analysis (arthroscopy versus ACLR) to address these sources of heterogeneity. Data from these subgroups were not pooled and were presented as is. If significant heterogeneity was observed ($I^2 > 50\%$) despite subgroup analysis, the degree to which the remaining factors (local anesthetic volume or local anesthetic dose) can predict the analgesic effect size of sensory block at 6 hours (primary outcome) was evaluated using meta-regression analysis.[39] In addition, we used sensitivity analysis to evaluate the impact of inclusion or exclusion of studies where inclusion was debatable.[40]

RESULTS

Search Results

A total of 161 records (after elimination of duplicates) were identified through our systematic databases search, of which 120 records were excluded on initial screening. We assessed 41 full-text manuscripts for eligibility and excluded 31 studies, including 1 trial that examined the intervention of interest but did not use multimodal analgesia.[16] Ten studies met the inclusion criteria and were included in this review by the consensus of all authors.[13,15,17–23,41] Figure 1 summarizes the Preferred Reporting Items for Systematic Reviews and Meta-Analyses flowchart.[24]

Trial Characteristics

Data from 10 RCTs yielded 714 patients, including 358 in the intervention arm and 356 in the comparator arm. The variants of ACB examined in the intervention arm were described as ACB in 6 RCTs,[13,15,18,20,21,41] saphenous nerve block in 1,[17] infrapatellar nerve block in 2,[19,22] and a combination of saphenous and posterior obturator nerve blocks in 1.[23] The latter in specific was included as it is thought that ACB routinely spreads to block the posterior obturator nerve.[6] The comparator arm was placebo injection in 7 RCTs[18–23,41] and a FNB in 3.[13,15,17] The type of surgeries included simple knee arthroscopy in 4 RCTs,[18,20,22,23] ACLR in 5 RCTs,[13,15,17,19,21] and 1 RCT involved both surgical procedures.[41] Intraoperatively, 9 studies[13,15,18–23,41] used a general anesthetic, while 1 study used a spinal anesthetic.[17] Eight studies[13,17,18,20–23,41] were conducted in an ambulatory setting, while patients had a 23-hour stay in 1 study,[15] and 1 RCT had a combination of both dispositions.[19] Analgesic outcomes (at least resting pain and 24-hour opioid consumption) were assessed in all of the RCTs reviewed. The details of study characteristics and the outcomes assessed are summarized in Table 1.

All studies used long-acting local anesthetics for their blocks, including 0.25% bupivacaine,[22] 0.5% bupivacaine,[17] 0.5% ropivacaine,[13,15,18] 0.75% ropivacaine,[20,21,23,41] and 0.5% levobupivacaine.[19] The median volume of local anesthetic used in our review was 15 mL (range: 7.5–30 mL). Epinephrine was the only additive used in the trials examined, and it was added to local anesthetics in 3 RCTs.[13,17,18] The blocks were administered before surgery in 6 trials,[13,17–19,22,23] before emergence in 3 trials,[15,20,21] and in the postanesthesia care unit (post-surgery) in one trial.[41] The level of the block was midthigh in 9 RCTs[13,15,18–23,41] and distal thigh in 1 study.[17] Ultrasound guidance was used to perform the blocks in all included studies. Supplementary analgesic techniques were used in 3 RCTs, including injection of local anesthetics subcutaneously,[18] intraarticularly,[19] and performing an obturator block (posterior branch).[23] Table 2 summarizes the details of the block technique and perioperative analgesic regimen used.

Risk of Bias Assessment

The reviewers' consensus assessment of the risk of bias is detailed in Figure 2. The overall methodologic quality of the reviewed trials was high, and the overall risk of bias across the studies was low. Most studies adequately described the methods used for randomization and allocation concealment barring 1 RCT.[15] Blinding of participants and personnel was assigned an unclear risk of bias in 2 studies,[15,18] and blinding of outcome assessors was also assigned an unclear risk of bias in another 2 studies.[19,23] The risks of attrition and selective reporting were decidedly low across all trials. Two additional studies were judged to have an unclear risk for other biases because 1 had a single author,[15] while another involved protocol amendment.[41]

Rest Pain at 6 Hours (Primary Outcome)

Data regarding resting pain at 6 hours postoperatively (primary outcome) were available from 9 studies, including 331 patients in the ACB group and 332 patients in the comparator group. This included 4 studies in the arthroscopy subgroup[18,22,23,41] and another 5 in the ACLR subgroup, of which 2 compared ACB to placebo[19,21] and 3 compared it to FNB.[13,15,17]
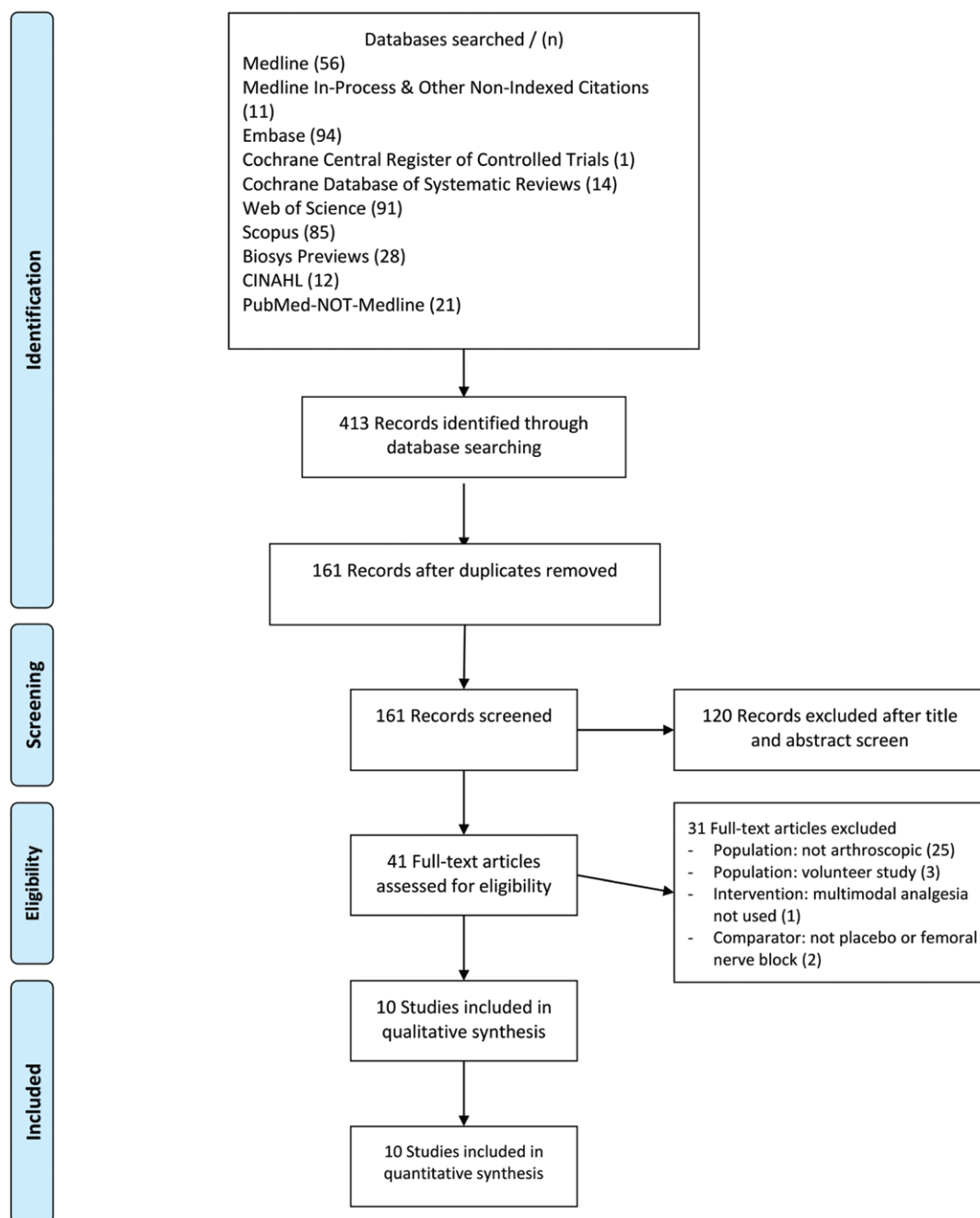
Administering ACB for knee arthroscopy reduced the resting VAS pain scores at 6 hours by a MD (95% CI) of −0.51 cm (−0.92 to −0.10) ($P = .02$, $I^2 = 0\%$) compared to placebo (Figure 3).

Administering ACB for knee ACLR had no effect on resting pain at 6 hours, whether compared to control (−0.22 cm [−0.69 to 0.25] [$P = .35$, $I^2 = 13\%$]) or FNB (−0.17 cm [−0.68 to 0.35] [$P = .52$, $I^2 = 0\%$]). The results are summarized in Table 3.

When subgrouped by type of procedure and nature of comparator, the primary outcome results were characterized by low heterogeneity, mitigating the need for further exploration of its sources. Evaluation of publication bias using visual assessment of Begg funnel plot and Egger regression test ($P = .20$; Figure 4) suggested the absence of such bias.

Resting Pain at Other Time Points

In knee arthroscopy, ACB reduced rest pain scores at 0 and 8 hours by −1.46 (−2.03 to −0.90) ($P < .00001$, $I^2 = 0\%$) and −0.58 (−0.93 to −0.04) ($P = .03$, $I^2 = 0\%$), respectively,

Databases searched / (n)
Medline (56)
Medline In-Process & Other Non-Indexed Citations (11)
Embase (94)
Cochrane Central Register of Controlled Trials (1)
Cochrane Database of Systematic Reviews (14)
Web of Science (91)
Scopus (85)
Biosys Previews (28)
CINAHL (12)
PubMed-NOT-Medline (21)

413 Records identified through database searching

161 Records after duplicates removed

161 Records screened → 120 Records excluded after title and abstract screen

41 Full-text articles assessed for eligibility → 31 Full-text articles excluded
- Population: not arthroscopic (25)
- Population: volunteer study (3)
- Intervention: multimodal analgesia not used (1)
- Comparator: not placebo or femoral nerve block (2)

10 Studies included in qualitative synthesis

10 Studies included in quantitative synthesis

From: Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). *Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement.* PLoS Med 6(7): e1000097. doi:10.1371/journal.pmed1000097

For more information, visit www.prisma-statement.org.

Figure 1. PRISMA flow diagram summarizing retrieved, included, and excluded RCTs.[24] CINAHL indicates Cumulative Index to Nursing and Allied Health Literature; Embase, Excerpta Medica database; PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses; RCT, randomized controlled trial.

compared to placebo (Figures 3 and 5). The point estimate for ACB favored reduced rest pain scores at 12 hours, but the 95% CI crossed the line of no difference. The effect of ACB on rest pain at 24 hours was not different from placebo. In knee ACLR, ACB was not different from placebo or FNB for this outcome at any of the time points examined (Table 3).

Dynamic Pain

For knee arthroscopy, ACB reduced dynamic pain scores at 0, 6, and 8 hours by −1.50 cm (−2.10 to −0.90) ($P < .00001$, $I^2 = 94\%$), −0.50 cm (−0.95 to −0.04) ($P = .03$, $I^2 = 0\%$), and −0.59 cm (−1.12 to −0.05) ($P < .00001$, $I^2 = 0\%$), respectively, compared to placebo, but not at 12 or 24 hours (Table 3).

Table 1. Study Characteristics and Outcomes Assessed

Author/Year	Type of Surgery	N	Groups (n)	Intraoperative Anesthesia	Admission Status	Resting Pain	Dynamic Pain	Opioid Consumption	Nausea or Vomiting	Antiemetic Use	Sedation	Time to First Analgesic Request	Patient Satisfaction	ACB Block Success	Quadriceps Strength	Block-Related Complications
Arthroscopy subgroup: ACB versus placebo																
Espelund et al[20] (2014)	Minor arthroscopic knee surgery	72	1. ACB (36) 2. Placebo (36)	GA	Outpatients	●	●	●								●
Espelund et al[41] (2014)	ACLR and other arthroscopic knee surgery	24	1. ACB (11) 2. Placebo (13)	GA	Outpatients	●	●	●						●		
Hanson et al[18] (2013)	Meniscectomy	50	1. ACB (25) 2. Placebo (25)	GA	Outpatients	●		●	●	●				●		●
Hsu et al[22] (2013)	Meniscectomy, meniscal repair, synovial debridement, microfracture	68	1. Infrapatellar NB (34) 2. Placebo (34)	GA	Outpatients	●		●						●		
Westergaard et al[23] (2014)	Meniscectomy, synovectomy, loose body removal, chondroplasty	59	1. Saphenous + posterior obturator branch (29) 2. Placebo (30)	GA	Outpatients	●	●	●	●	●		●				●
ACLR subgroup: ACB versus placebo																
Espelund et al[21] (2013)	ACLR	49	1. ACB (25) 2. Placebo (24)	GA	Outpatients	●	●	●	●	●	●					●
Espelund et al[41] (2014)	ACLR and other arthroscopic knee surgery	24	1. ACB (13) 2. Placebo (11)	GA	Outpatients	●	●	●						●		
Lundblad et al[19] (2011)	ACLR	62	1. Infrapatellar NB (30) 2. Placebo (32)	GA	Inpatient + Outpatients	●	●	●						●		
ACLR subgroup: ACB versus FNB																
Abdallah et al[13] (2016)	ACLR	100	1. ACB (50) 2. FNB (50)	GA	Outpatients	●		●	●	●		●	●	●	●	●
Chisholm et al[17] (2014)	ACLR	80	1. Saphenous NB (39) 2. FNB (41)	SA	Outpatients	●		●	●	●	●		●			
Ahl[15] (2015)	ACLR	128	1. ACB (64) 2. FNB (64)	GA	Inpatient	●		●							●	●

Blank spaces indicate not assessed. Bullets indicate assessed.
Abbreviations: ACB, adductor canal block; ACLR, arthroscopic cruciate ligament reconstruction; FNB, femoral nerve block; GA, general anesthesia; NB, nerve block; SA, spinal anesthesia.

Table 2. ACB Technique and Analgesic Regimen

| Author/Year | Local Anesthetic | | | | Block Technique | | | | Analgesic Regimens | | | | |
	Drug	Concentration, %	Volume (mL)	Additives	Block Timing	Injection Site	Block Technique	Supplementary Block(s)	Preoperative	Intraoperative	PACU	Post-PACU Discharge or at Home
Arthroscopy subgroup: ACB versus placebo												
Espelund et al[20] (2014)	Ropivacaine	0.75	30	No	Postsurgery	Midthigh	USG	None	Oral 1 g acetaminophen, oral 400 mg ibuprofen	IV remifentanil, IV sufentanil	IV ketobemidone	Oral acetaminophen, oral ketobemidone
Espelund et al[41] (2014)	Ropivacaine	0.75	30	No	Postsurgery	Midthigh	USG	None	Oral 1 g acetaminophen, oral 400 mg ibuprofen	IV remifentanil, IV sufentanil	IV sufentanil	ND
Hanson et al[18] (2013)	Ropivacaine	0.50	15	Epinephrine, 1:400,000	Presurgery	Midthigh	USG	Port site infiltration (bupivacaine)	Oral 400 mg celecoxib	IV fentanyl	IV fentanyl, then oral oxycodone	Oral acetaminophen, oral ibuprofen, oral opioids
Hsu et al[22] (2013)	Bupivacaine	0.25	10	No	Presurgery	Midthigh	USG	None	ND	IV fentanyl	IV ketorolac, IV hydro-morphone, oral hydro-morphone/acetaminophen	Oral hydromorphone/acetaminophen
Westergaard et al[23] (2014)	Ropivacaine	0.75	7.5	No	Presurgery	Midthigh	USG	Posterior branch of obturator nerve (ropivacaine)	ND	IV sufentanil	Oral acetaminophen, IV morphine	Oral morphine
ACLR subgroup: ACB versus placebo												
Espelund et al[21] (2013)	Ropivacaine	0.75	30	No	Postsurgery	Midthigh	USG	None	Oral 1 g acetaminophen, oral 400 mg ibuprofen	IV remifentanil, IV sufentanil	IV ketobemidone	Oral acetaminophen, oral ibuprofen, oral ketobemidone
Espelund et al[41] (2014)	Ropivacaine	0.75	30	No	Postsurgery	Midthigh	USG	None	Oral 1 g acetaminophen, oral 400 mg ibuprofen	IV remifentanil, IV sufentanil	IV sufentanil	ND
Lundblad et al[19] (2011)	Levo-bupivacaine	0.50	10	No	Presurgery	Midthigh	USG	Skin infiltration (ropivacaine), intraarticular (ropivacaine, morphine, ketorolac)	Oral 1–2 g acetaminophen, IV 2.5–7.5 mg ketobemidone	IV fentanyl	IV ketobemidone	Oral codeine/acetaminophen, oral diclofenac

(Continued)

Table 2. Continued

	Local Anesthetic			Block Technique				Supplementary Block(s)	Analgesic Regimens			
Author/Year	Drug	Concentration, %	Volume (mL)	Additives	Block Timing	Injection Site	Block Technique		Preoperative	Intraoperative	PACU	Post-PACU Discharge or at Home
ACLR subgroup: ACB versus FNB												
Abdallah et al[13] (2016)	Ropivacaine	0.50	20	Epinephrine, 1:200,000	Presurgery	Midthigh	USG	None	Oral 1 g acetaminophen, oral 400 mg celecoxib	IV fentanyl, IV morphine	IV fentanyl, IV hydromorphone, IV morphine	Oral codeine/acetaminophen, oral oxycodone/acetaminophen
Chisholm et al[17] (2014)	Bupivacaine	0.50	10	Epinephrine, 1:200,000	Presurgery	Distal thigh	USG	None	ND	IV ketorolac	IV hydromorphone, oral opioids	Oral opioids, NSAIDs
Ahl[15] (2015)	Ropivacaine	0.50	15	No	Postsurgery	Midthigh	USG	None	ND	IV fentanyl	IV acetaminophen, IV ketorolac	IV acetaminophen, IV ketorolac

Abbreviations: ACB, adductor canal block; ACLR, arthroscopic cruciate ligament reconstruction; FNB, femoral nerve block; IV, intravenous; ND, not defined; NSAID, nonsteroidal anti-inflammatory drug; PACU, postanesthesia care unit; USG, ultrasound guided.
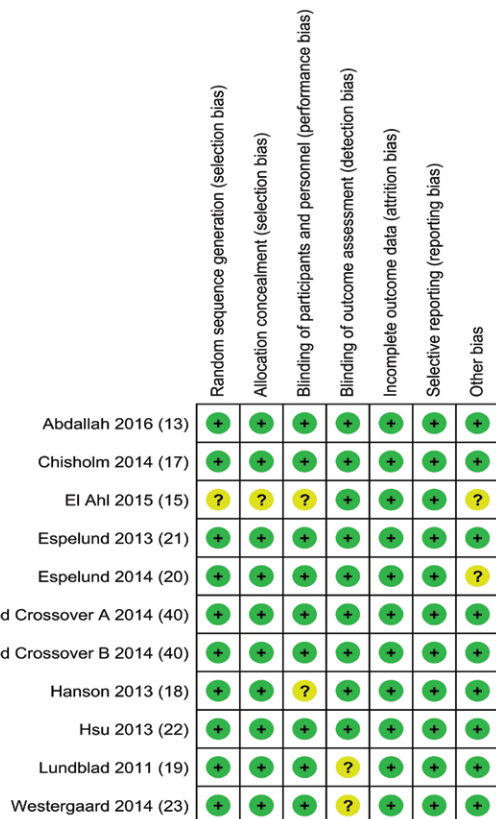

Figure 2. Risk of bias summary using the Cochrane risk of bias tool.[26] ? indicates unclear risk; –, high risk; and +, low risk.

For knee ACLR, ACB did not have an effect on dynamic pain scores at any of the points examined compared to placebo (Table 3). None of the trials comparing ACB to FNB reported the effect on dynamic pain.

Time for First Analgesic Request

With respect to time to first analgesic request, only 1 study in the arthroscopy subgroup[23] and another in the ACLR group[13] compared ACB to placebo and FNB, respectively. ACB failed to prolong the time to first analgesic request in these trials.

Cumulative 24-Hour Opioid Consumption

For knee arthroscopy, ACB reduced the cumulative 24-hour oral morphine equivalent consumption by −7.41 mg (−14.75 to −0.08) ($P = .05$, $I^2 = 48\%$) compared to placebo (Figure 6, Table 3). For knee ACLR, ACB was not different from placebo or FNB for this outcome.

Opioid-Related Adverse Effects

None of the trials examined reported significant differences between the study groups in the risk of postoperative nausea and vomiting, in antiemetic use, or in postoperative sedation (Table 3).

Patient Satisfaction

Only 2 studies in the ACLR subgroup assessed patient satisfaction.[13,17] Neither reported improvement in satisfaction with ACB compared to FNB (Table 3).
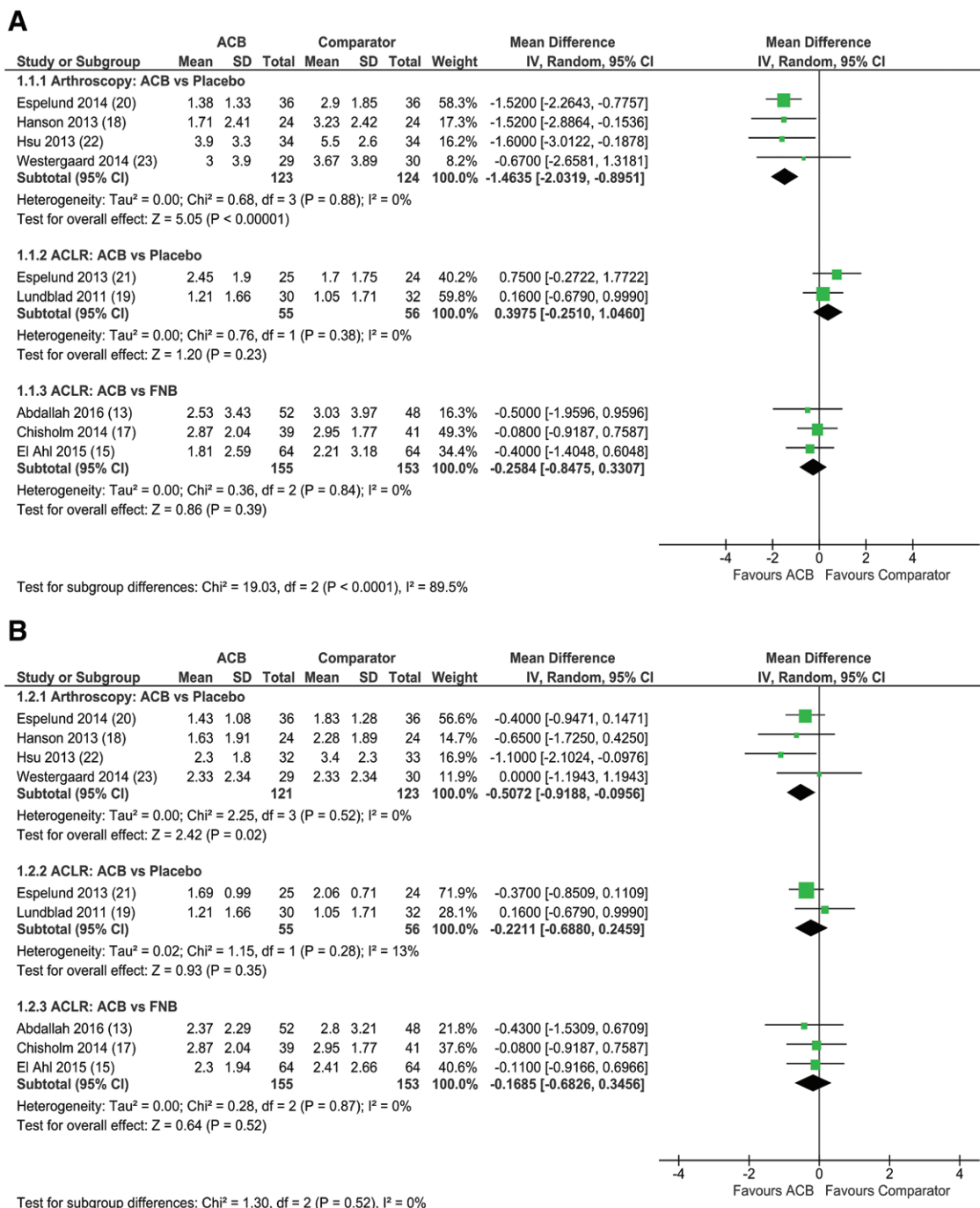
Figure 3. Forest plot depicting resting pain at (A) 0 h and (B) 6 h. The pooled estimates of the mean difference are shown. The 95% CIs are shown as lines for individual studies and as diamonds for pooled estimates. ACB indicates adductor canal block; ACLR, anterior cruciate ligament reconstruction; CI, confidence interval; df, degrees of freedom; FNB, femoral nerve block; IV, intravenous; SD, standard deviation.

Block-Related Outcomes

ACB success was assessed in 5 studies,[13,18,19,22,41] reporting 179 successful blocks out of 190 performed, or a cumulative rate of 94.2%.

Quadriceps strength was evaluated in 2 studies in the ACLR subgroup[13,15]; ACB reduced the maximal voluntary isometric contraction by 26.2% compared to 79.4% for the FNB in the first hour postoperatively.

ACB-related complications were assessed in 7 trials,[13,15,18–22] and only 1[20] reported 2 complications, including transient muscle cramps and compromised quadriceps strength. It was unclear whether these complications were block or surgery related.

DISCUSSION

Our review reveals the limited analgesic role of ACB in ambulatory arthroscopic knee surgery. ACB introduces clinically modest analgesic benefits when administered to patients having simple knee arthroscopy procedures in the setting of multimodal analgesia. Compared to placebo,

Table 3. Results Summary

Outcome	Subgroup	Studies Included	ACB Mean or n/N	Comparator Group Mean or n/N	MD or OR (95% CI)	P Value for Statistical Significance	I² Test for Heterogeneity, %	P Value for Heterogeneity
Resting pain at 0 h (cm)	Arthroscopy: ACB versus placebo	18,20,22,23	123	124	−1.46 (−2.03 to −0.90)	<.00001	0	.88
	ACLR: ACB versus placebo	19,21	55	56	0.40 (−0.25 to 1.05)	.23	0	.38
	ACLR: ACB versus FNB	13,15,17	155	153	−0.26 (−0.85 to 0.33)	.39	0	.84
Resting pain at 6 h (cm)	Arthroscopy: ACB versus placebo	18,20,22,23	121	123	−0.51 (−0.92 to −0.10)	.02	0	.52
	ACLR: ACB versus placebo	19,21	55	56	−0.22 (−0.69 to 0.25)	.35	13	.28
	ACLR: ACB versus FNB	13,15,17	155	153	−0.17 (−0.68 to 0.35)	.52	0	.87
Resting pain at 8 h (cm)	Arthroscopy: ACB versus placebo	20,23	65	66	−0.48 (−0.93 to −0.04)	.03	0	.88
	ACLR: ACB versus placebo	19,21	55	56	−0.25 (−0.72 to 0.22)	.30	27	.24
	ACLR: ACB versus FNB	17	39	41	−0.08 (−0.92 to 0.76)	.85	N/A	N/A
Resting pain at 12 h (cm)	Arthroscopy: ACB versus placebo	18,20,22,23	86	87	−0.85 (−1.71 to 0.01)	.05	39	.19
	ACLR: ACB versus placebo	19	30	32	0.16 (−0.68 to 1.00)	.71	N/A	N/A
	ACLR: ACB versus FNB	13,15,17	155	153	−0.33 (−0.87 to 0.21)	.23	0	.68
Resting pain at 24 h (cm)	Arthroscopy: ACB versus placebo	18,20,22,23	121	123	−0.44 (−1.28 to 0.40)	.30	75	.008
	ACLR: ACB versus placebo	19,21	55	56	0.25 (−0.15 to 0.65)	.22	0	.38
	ACLR: ACB versus FNB	13,15,17	155	153	0.34 (−1.74 to 2.43)	.75	92	<.00001
Dynamic pain at 0 h (cm)	Arthroscopy: ACB versus placebo	13,20,23,41	76	78	−1.50 (−2.10 to −0.90)	<.00001	94	<.00001
	ACLR: ACB versus placebo	19,21,41	68	67	−0.39 (−1.08 to 0.30)	.27	72	.03
	ACLR: ACB versus FNB	N/A	N/A	N/A	Not estimable	N/A	N/A	N/A
Dynamic pain at 6 h (cm)	Arthroscopy: ACB versus placebo	20,23	65	64	−0.50 (−0.95 to −0.04)	.03	0	.77
	ACLR: ACB versus placebo	19,21	55	56	−0.05 (−0.61 to 0.50)	.86	0	.62
	ACLR: ACB versus FNB	N/A	N/A	N/A	Not estimable	N/A	N/A	N/A
Dynamic pain at 8 h (cm)	Arthroscopy: ACB versus placebo	20,23	65	65	−0.59 (−1.12 to −0.05)	.03	0	.54
	ACLR: ACB versus placebo	19,21	55	56	−0.36 (−0.92 to 0.20)	.21	8	.30
	ACLR: ACB versus FNB	N/A	N/A	N/A	Not estimable	N/A	N/A	N/A
Dynamic pain at 12 h (cm)	Arthroscopy: ACB versus placebo	23	29	30	−0.66 (−1.85 to 0.53)	.28	N/A	N/A
	ACLR: ACB versus placebo	19	30	32	0.23 (−1.03 to 1.48)	.72	N/A	N/A
	ACLR: ACB versus FNB	N/A	N/A	N/A	Not estimable	N/A	N/A	N/A
Dynamic pain at 24 h (cm)	Arthroscopy: ACB versus placebo	20,23	65	64	−0.02 (−0.84 to 0.80)	.96	45	.18
	ACLR: ACB versus placebo	19,21	54	56	0.19 (−0.56 to 0.94)	.62	43	.19
	ACLR: ACB versus FNB	N/A	N/A	N/A	Not estimable	N/A	N/A	N/A
24-h opioid consumption (mg)	Arthroscopy: ACB versus placebo	18,20,22,23	124	123	−7.41 (−14.75 to −0.08)	.05	48	.12
	ACLR: ACB versus placebo	19,21	55	56	0.40 (−19.81 to 20.61)	.97	74	.05
	ACLR: ACB versus FNB	13,15,17	155	153	1.95 (−3.15 to 7.05)	.45	82	.45
Nausea or vomiting (n/N)	Arthroscopy: ACB versus placebo	18,23	11/73	10.0/74	1.03 (0.35–3.03)	.96	0	.97
	ACLR: ACB versus placebo	21	1/25	0/24	3.00 (0.12–77.31)	.51	N/A	N/A
	ACLR: ACB versus FNB	13,17	35/91	41/89	0.75 (0.31–1.82)	.52	54	.14
Antiemetic use (n/N)	Arthroscopy: ACB versus placebo	18,23	4/53	6.0/54	0.65 (0.17–2.52)	.54	0	.74
	ACLR: ACB versus placebo	21	4/25	3/25	1.33 (0.27–6.70)	.73	N/A	N/A
	ACLR: ACB versus FNB	17	9.0/39	9/41	1.07 (0.37–3.05)	.90	N/A	N/A
Sedation (n/N)	Arthroscopy: ACB versus placebo	N/A	N/A	N/A	Not estimable	N/A	N/A	N/A
	ACLR: ACB versus placebo	21	2/25	6.0/24	0.26 (0.05–1.45)	.12	N/A	N/A
	ACLR: ACB versus FNB	17	26.0/39.0	27/41	1.04 (0.41–2.62)	.94	N/A	N/A
Patient satisfaction	Arthroscopy: ACB versus placebo	N/A	N/A	N/A	Not estimable	N/A	N/A	N/A
	ACLR: ACB versus placebo	N/A	N/A	N/A	Not estimable	N/A	N/A	N/A
	ACLR: ACB versus FNB	13,17	91	89	−0.02 (−0.59 to 0.54)	.93	72	.06

Abbreviations: ACB, adductor canal block; ACLR, anterior cruciate ligament reconstruction; CI, confidence interval; FNB, femoral nerve block; MD, mean difference; N/A, not applicable; OR, odds ratio.

Figure 4. Funnel plot assessing publication bias for resting pain at 6 h. Plotted is the SE versus MD. Vertical line represents the combined effect for pain, and the diagonal lines designate the expected 95% confidence intervals from the combined effect. Studies outside the funnel indicate heterogeneity. ACB indicates adductor canal block; ACLR, anterior cruciate ligament reconstruction; FNB, femoral nerve block; MD, difference in mean; SE, standard error.
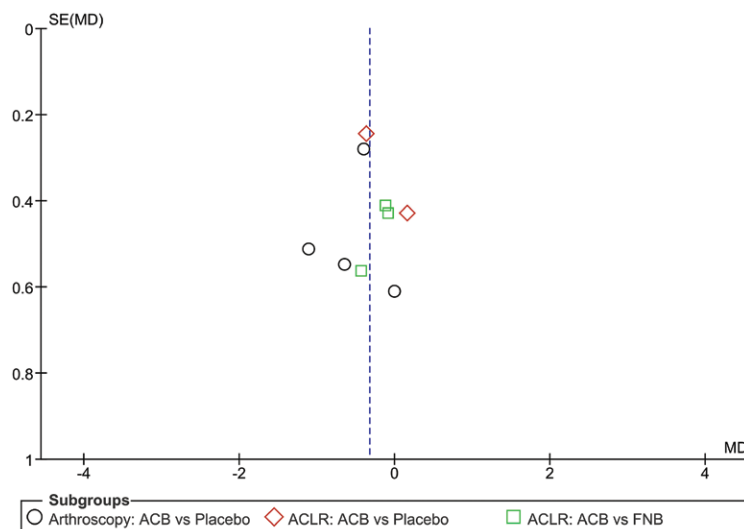
ACB marginally improved resting and dynamic pain up to 8 hours and reduced cumulative 24 hours analgesic consumption while preserving motor strength after simple knee arthroscopy. In contrast, administering ACB to patients having arthroscopic ACLR in the setting of multimodal analgesia did not improve analgesic outcomes, regardless of whether ACB was compared to placebo or FNB. These findings should be interpreted with caution, considering the paucity of trials examining the role of ACB in ambulatory arthroscopic knee surgery.

Novelty

This is the first meta-analysis to quantitatively demonstrate the analgesic efficacy of ACB in arthroscopic knee surgery. A previous meta-analysis by Jin et al[42] concluded that ACB offers no analgesic benefit for arthroscopic knee surgery, but these results were inconclusive as the authors combined the data of knee arthroscopy and arthroplasty together, and evaluated pain relief at 24 hours after administering the ACB as a primary outcome, a time when the effects of ACB would have worn off.

Clinical Implications

Our review has several important clinical implications. First, simple knee arthroscopy has been generally considered as a procedure where multimodal analgesia excluding nerve blocks provides sufficient pain relief.[43,44] This review confirms this assumption and provides evidence that patients having arthroscopy may derive clinically marginal analgesic benefits from the ACB. Second, our review challenges the common beliefs and practices regarding the analgesic role of nerve blocks in ACLR. The comparison of ACB to placebo (3 RCTs, 135 patients) indicates that ACB does not improve analgesia after ACLR, while the comparison between FNB and ACB (3 RCTs, 308 patients) indirectly undermines the potential analgesic role of FNB. It is noteworthy that an earlier review by Mall and Wright[45] did signal the limited role of FNB in ACLR. This indirect evidence intensifies the concern over using FNB, given the recent data suggesting that it may be associated with persistent strength deficits at 6 months after ACLR.[46–48] Nonetheless,

definitive evidence regarding the role of the FNB in ACLR should be based on direct comparisons with placebo. Overall, the evidently limited analgesic role of nerve blocks in ACLR may be explained by lack of efficacy in treating pain originating from graft sites, lack of additional benefit in the setting of multimodal analgesia, or a combination of these 2 hypotheses.

Anatomical Considerations

The observed difference in the analgesic efficacy of ACB between simple arthroscopy and ACLR procedures may reflect the diverse innervation of the anatomical areas involved, which includes the femoral nerve and its infrapatellar and saphenous branches, the obturator nerve, as well as the tibial and common peroneal branches of the sciatic nerve. Therefore, surgical variables, namely the location of surgical ports and the source of grafts used, practically dictate the choice and role of nerve blocks to be used in the multimodal analgesic regimen. Failure to account for these variables in the analgesic plan may result in significant postoperative pain severity, primarily because of the challenges of pain emanating from multiple sites and the lack of donor-site analgesia.

For simple arthroscopy, the anterolateral (camera), anteromedial (instrumentation), and superomedial ports (fluid channel) are innervated by the common peroneal, infrapatellar, and saphenous nerves, respectively.[49,50] Additional vertical incisions (anteromedial port) are also likely to transect the overlying nerves, such as the infrapatellar nerve.[51] Therefore, from a purely anatomical perspective, an ACB can potentially provide some analgesic benefits for this procedure. Nonetheless, the magnitude of these benefits is not clinically important, nor does it justify administering ACB as an intervention.

For ACLR, the aforementioned innervations are applicable, in addition to that of the grafts used, which can be either hamstring graft or bone-patellar tendon-bone graft (bone-tendon-bone).[52] The hamstring graft is harvested from the semitendinosus and gracilis muscles tendons innervated by the tibial and obturator nerves, respectively, and the skin incision made over the anteromedial aspect of tibial
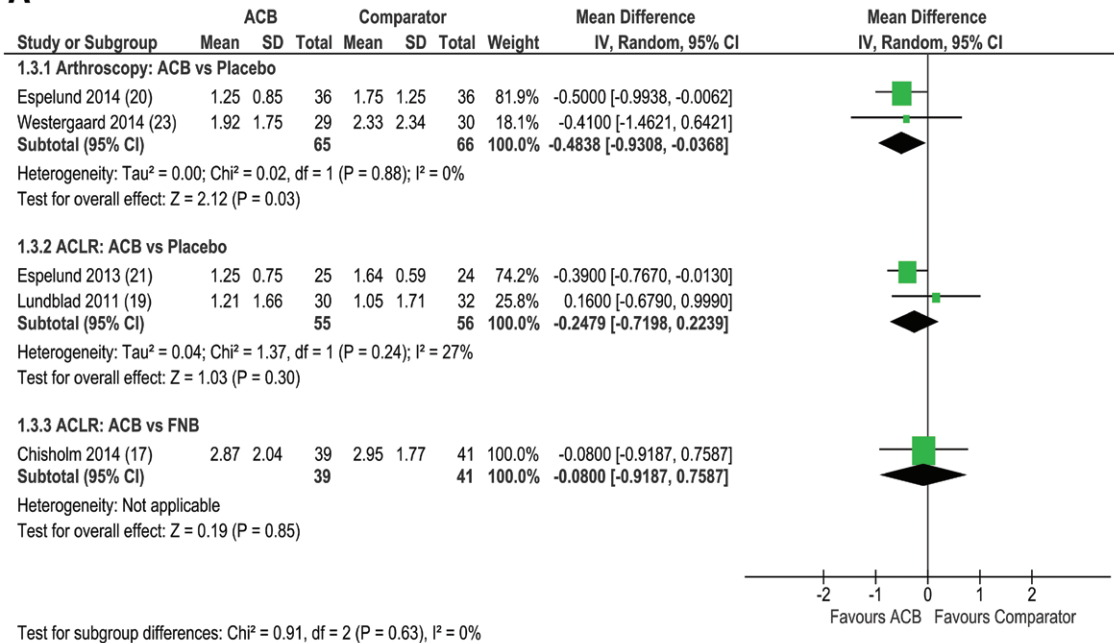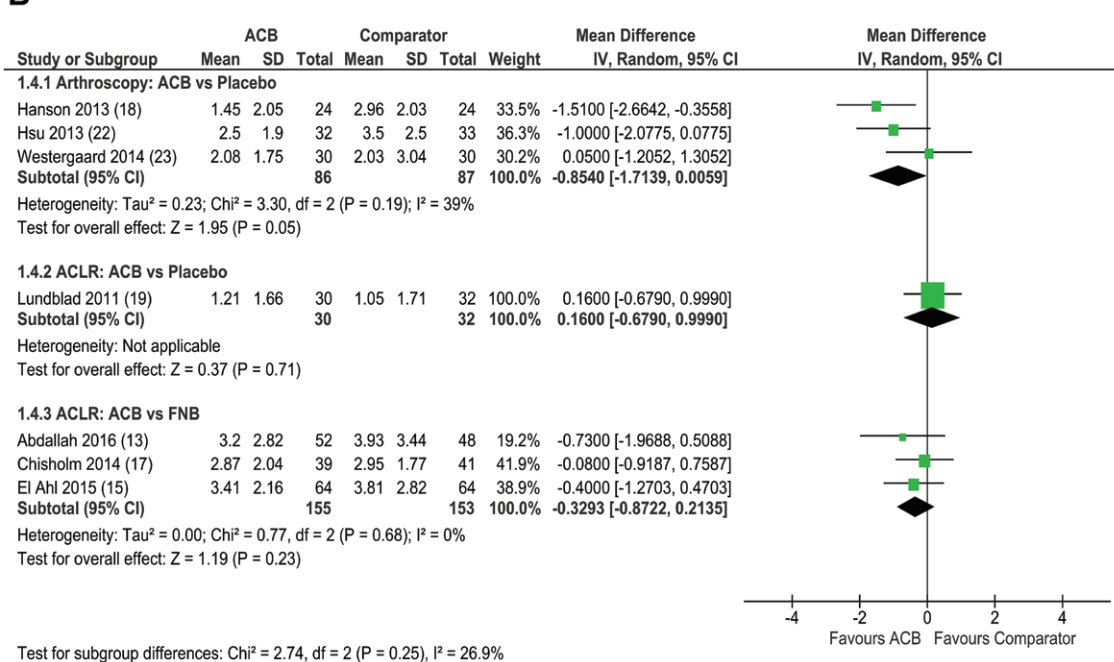
Figure 5. Forest plot depicting resting pain at (A) 8 h and (B) 12 h. The pooled estimates of the mean difference are shown. The 95% CIs are shown as lines for individual studies and as diamonds for pooled estimates. ACB indicates adductor canal block; ACLR, anterior cruciate ligament reconstruction; CI, confidence interval; df, degrees of freedom; FNB, femoral nerve block; IV, intravenous; SD, standard deviation.

plateau is supplied by the infrapatellar nerve. The graft is positioned through anteromedial tibial[53] and posterolateral femoral condylar tunnels,[54] innervated by both femoral and common peroneal nerves. In contrast, the bone-tendon-bone graft is harvested through an 8- to 10-cm long longitudinal incision over the anterior patella and upper tibia innervated by the femoral and infrapatellar nerves, respectively.[55] Positioning of this type of graft by drilling anterior tibial and femoral tunnels (supplied by the femoral nerve)

is particularly painful.[56,57] These anatomical considerations suggest that the ACB does not provide complete analgesia for this ACLR, particularly when a hamstring graft is used.

ACB Technique
There is an ongoing controversy regarding what constitutes an ACB and the effect of injection location on postoperative analgesia and motor power.[58–60] This is likely a result of differences in the contemporary definitions and
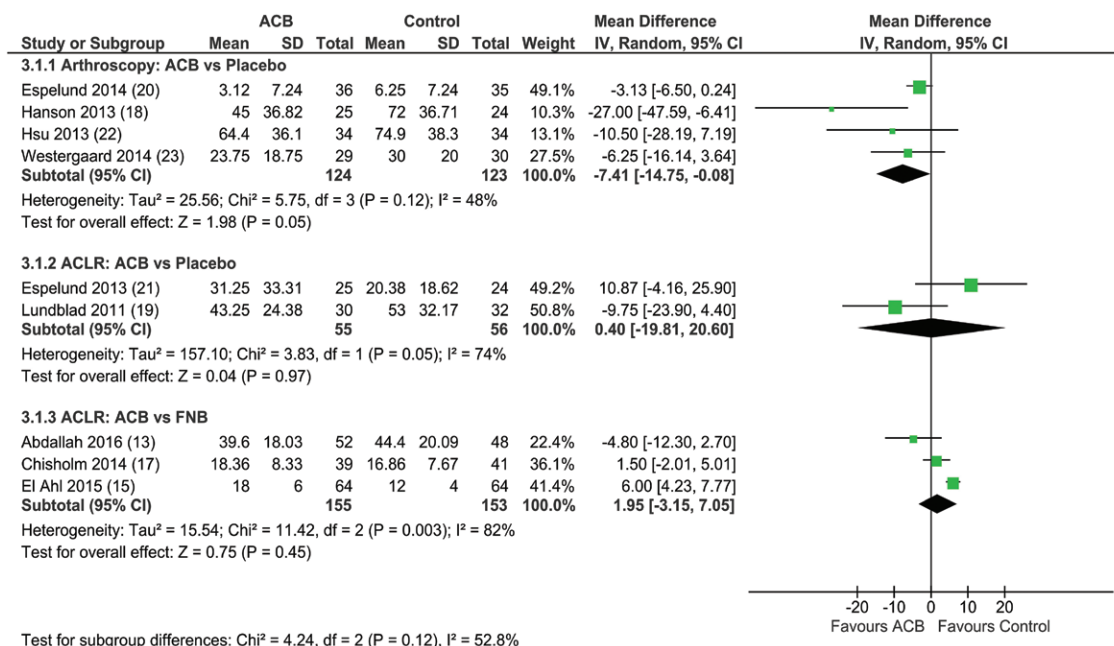
Figure 6. Forest plot depicting 24-h opioid consumption. The pooled estimates of the mean difference are shown. The 95% CIs are shown as lines for individual studies and as diamonds for pooled estimates. ACB indicates adductor canal block; ACLR, anterior cruciate ligament reconstruction; CI, confidence interval; df, degrees of freedom; FNB, femoral nerve block; IV, intravenous; SD, standard deviation.

anatomical boundaries of the femoral triangle and the adductor canal.[61,62] An example of such controversy is the midthigh injection: some studies have used it as the standard technique for administering an ACB[63]; in contrast, other studies consider it as a subsartorial approach to the femoral triangle[59] that primarily blocks femoral nerve branches (including the nerve to vastus medialis) producing very limited or no distal spread within the adductor canal.[58,59] Furthermore, another group of studies considers ACB to be exclusively a result of injection in the distal thigh that consistently blocks the saphenous nerve and the posterior branch of the obturator nerve, without producing a significant cephalad spread.[6,58] The scarcity of clinical trials comparing the analgesic and motor-sparing effects of the various injection points has precluded identifying the ideal ACB technique.[64–66] For the purpose of this review, we included both midthigh[13,15,18–23,41] as well as the distal-thigh[17] injection sites.

Limitations and Strengths

Our review has several limitations. The included studies involved diverse surgical settings. For example, simple arthroscopy included meniscectomy, chondroplasty, and microfracture, while ACLR included allograft and hamstring or patellar graft. Similarly, we observed differences in the block and perioperative analgesic regimens used; these included differences in ACB technique, type and dose of local anesthetic and/or additives used, and timing of block. It is likely that these factors may have contributed to the observed heterogeneity. As well, incomplete data regarding graft type precluded examining whether ACB was more effective for specific types of grafts used in ACLR. Additionally, only 1 study in our review[22] evaluated the quality of recovery and functional outcomes after arthroscopic knee surgery, precluding any meaningful conclusions

regarding these important outcomes.[67] Moreover, the trials reviewed were limited in size, which may increase type I error and the risk of estimation of treatment by publication bias. Also, individual patient data were not available for analysis, which prevented us from using composite measures of pain and opioid consumption.[68] Furthermore, data relating to preoperative knee pain severity, knee function, and psychological factors were unavailable, limiting the ability to analyze these confounders.[69–71] Likewise, none of the studies included in this review evaluated long-term outcomes, including chronic pain and functionality. Notably, other analgesic modalities with proven efficacy in arthroscopic procedures, such as intraarticular LIA[72] and graft donor-site infiltration,[73,74] were not examined; this precluded determining the role of ACB in the setting of such increasingly popular analgesic modalities. Similarly, the multimodal analgesic regimens most commonly used in the trials reviewed were limited to a combination of nonsteroidal anti-inflammatory drugs, cyclooxygenase-2 inhibitor, or acetaminophen with an opioid as rescue. Finally, we examined analgesic outcomes up to 24 hours only; thus, we could not determine whether ACB is associated with rebound pain, a phenomenon previously documented with the use of FNB for ACLR.[75]

In contrast, our review has several strengths. Our search strategy was comprehensive and included 10 databases; furthermore, we limited the inclusion to RCTs. Our results were analyzed using predefined subgroups to avoid pooling different surgical procedures or comparators. Moreover, heterogeneity of most outcome results was low to moderate, and a combination of meta-regression and sensitivity analysis was used to explore heterogeneity when it was high. Finally, evaluation of our secondary outcome results was exploratory and hypothesis generating to avoid overstating or inflating type I error. These factors emphasize the validity of our results.

CONCLUSIONS

Our findings from a small number of trials suggest a limited analgesic role for the ACB in ambulatory arthroscopic knee surgery. Administering ACB to patients having minor arthroscopic knee surgery is associated with improvement in pain control up to 8 hours and reduction in the 24-hour opioid consumption, but these benefits were clinically modest. As for ACLR, administering ACB was not associated with any benefits, and ACB was not different from control or FNB, signaling a limited role of both blocks in this procedure. Future studies are needed to determine the role of ACB in the setting of LIA and graft donor-site analgesia. ■■

DISCLOSURES

Name: Herman Sehmbi, MD, EDRA, EDAIC.
Contribution: This author helped design and conduct the study, analyze the data, and prepare and approve the final manuscript.
Conflicts of Interest: None.
Name: Richard Brull, MD, FRCPC.
Contribution: This author helped conduct the study, analyze the data, and prepare and approve the final manuscript.
Conflicts of Interest: None.
Name: Ushma Jitendra Shah, DA, DNB, EDRA, EDAIC, FRCA.
Contribution: This author helped conduct the study, analyze the data, and prepare and approve the final manuscript.
Conflicts of Interest: None.
Name: Kariem El-Boghdadly, FRCA.
Contribution: This author helped design and conduct the study, collect and analyze the data, and prepare and approve the final manuscript.
Conflicts of Interest: None.
Name: David Nguyen, MD.
Contribution: This author helped design and conduct the study, collect and analyze the data, and prepare the final manuscript.
Conflicts of Interest: None.
Name: Girish P. Joshi, MBBS, MD, FFARCSI.
Contribution: This author helped design and conduct the study, and prepare and approve the final manuscript.
Conflicts of Interest: G. P. Joshi receives honoraria from Pacira Pharmaceuticals, Mallinckrodt Endotracheal Tubes, and Merck Pharmaceuticals.
Name: Faraj W. Abdallah, MD.
Contribution: This author helped design and conduct the study, collect and analyze the data, and prepare and approve the final manuscript.
Conflicts of Interest: F. W. Abdallah is the archival author.
This manuscript was handled by: Honorio T. Benzon, MD.

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