Original Article

Adductor canal block (ACB) plus infiltration of the posterior capsule of the knee (iPACK) block versus 4-in-1 block in an arthroscopic anterior cruciate ligament (ACL) repair: A randomised study

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ABSTRACT

Background and Aims: Anterior cruciate ligament (ACL) repair is a common sports-related surgery requiring early rehabilitation. Injection between the popliteal artery and the capsule of the knee (iPACK) provides analgesia to the posterior knee and, when combined with adductor canal block (ACB), can provide complete analgesia for knee surgery. A 4-in-1 block, a single injection, has been studied for analgesia in TKR but not ACL repair. This study was done with the objective of comparing the postoperative analgesia of iPACK + ACB versus 4-in-1 block in ACL repair. **Methods:** The study was conducted on 184 participants undergoing ACL repair in the age group of 18–70 years. Patients were randomly allocated to iPACK +ACB or 4-in-1 block. After the preoperative and intraoperative protocol, a guided nerve block was performed. The duration of motor blockade of spinal anaesthesia and pain scores were monitored using the visual analogue scale (VAS), and the time for first rescue analgesia was noted at 3, 6, 12, 24, and 36 hours. An independent sample *t*-test was used to find the association of all quantitative variables, and a Chi-square test was used to find the association of categorical variables with both groups of patients ($P < 0.05$). **Results:** VAS scores were statistically similar between the two groups at 3, 6, 12, and 24 hours but were significantly less at 36 hours in group B ($P < 0.001$). The time to perform the regional block was lower in group B, a single injection technique ($P < 0.001$). None of the patients showed muscle weakness in the postoperative period and could cooperate reasonably with physiotherapy. **Conclusion:** The 4-in-1 block provides non-inferior analgesia compared to the established iPACK plus ACB for arthroscopic ACL surgery.

Keywords: Analgesia, anterior cruciate ligament, muscle weakness, nerve block, visual analog scale

INTRODUCTION

Anterior cruciate ligament (ACL) injury, the most common sports-related injury of the knee, has significant potential for postoperative pain, requiring an anaesthetic strategy with a combination of balanced analgesia, patient satisfaction, and early ambulation for full functional recovery and early discharge. Multi-modal analgesia with local or regional anaesthesia is considered ideal, but there is a lack of consensus on which strategy to utilise.[1,2]

Strategies with multi-modal analgesia include femoral nerve block (FNB), adductor canal blocks (ACB), ACB combined with injection between the popliteal artery and the capsule of the knee (iPACK) block, or

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analgesia with local infiltration (LIA). FNB is known to cause lower limb motor weakness of 49%–80%, resulting in the risk of falls during rehabilitation and mobilisation. ACB, a simple, reliably efficacious, and motor-preserving block, has been shown to produce only 8% motor involvement.[2-4] Patients undergoing arthroscopic ACL surgery with an FNB or ACB experience pain in the posterior part of the knee.[1,2] The sciatic nerve block (SNB), when combined with FNB in ACL repair surgery, provides improved analgesia and reduces opioid requirements. However, SNB can cause sensory-motor deficits, increasing fall risk during mobilisation for rehabilitation.[3] Hence, an optimal regional anaesthetic technique should provide analgesia to anterior and posterior knee nociceptors with no motor weakness.

iPACK, provides adequate analgesia for posterior knee pain while preserving motor function[5-9] and has been successfully combined with ACB for complete analgesia for ACL repair.[10-14] 4-in-1 block,[15,16] a single injection technique, has been compared in TKR with successful outcomes but has not been studied for ACL reconstruction. Hence, we hypothesised that postoperative analgesia provided by the single injection technique, 4-in-1 block, is comparable to the already established combination of iPACK with ACB for ACL repair. The study's primary objective was to compare the analgesia provided with the regional analgesia technique of iPACK + ACB versus 4-in-1 block on postoperative pain scores in patients undergoing arthroscopic ACL repair under sub-arachnoid block. The secondary objectives were to observe the rescue analgesic consumption and hospital length of stay (LOS) duration in the patients.

METHODS

After approval from the Institutional Ethics Committee (vide approval number ECR/68/Inst/OR/2013/RR-22, dated 23 May 2023, and trial registration at Clinical Trials Registry-India, (vide registration number CTRI/2023/07/054893; assessable at ctri.nic.in), the study was performed in patients undergoing unilateral arthroscopic ACL repair, with ages between 18 and 70 years of either gender, with complete preoperative check-ups and optimisation falling within the American Society of Anesthesiologists (ASA) physical status I–III. In this randomised controlled study, two groups were compared in a multi-specialty tertiary care hospital from June to November 2023. Exclusion criteria included patients with cardiopulmonary dysfunction or poor cardiac reserve with left ventricular ejection fraction ≤ 35%, with bleeding diathesis or coagulopathies, on anticoagulants aspirin or clopidogrel, infection at the site for block, contraindication for regional anaesthesia, allergies to local anaesthetics, previous neuropathy on the operative limb, and/or denial to consent for participation. Written informed consent was taken from all patients for participation in the study, with permission to use the data for educational and research purposes. The Declaration of Helsinki (2013) principles and Good Clinical Practice were followed for the study.

The regional analgesia technique was performed using portable ultrasonography (USG) machine (Sonosite™ Edge II™, Fujifilm Sonosite Inc., Bothell, Washington, USA), 10 cm – 22-G echogenic nerve block needle (Bbraun™ Stimuplex®, ultra 360®, Bbraun™, Melsungen, Hessen, Germany), 0.2% ropivacaine, dexmedetomidine (50 μg/mL), and 20 mL syringe (Dispovan single-use hypodermic syringe, Hindustan syringes and Medical Devices, Faridabad, Haryana, India). Surgical skin preparation (chlorhexidine gluconate 2% w/v, ethanol 80% v/v) antiseptic solution, sterile gauge, sterilised drapes, and sterilised camera cover were used for sterility.

Using a computer-generated random table (OpenEpi.com, Version 3, open-source calculator), patients were randomly allocated to either ACB + iPACK (Group A) or 4-in-1 block (Group B). The random group allocation was sealed in an opaque envelope by the operating room (OR) manager (A0) and handed over to the senior anaesthesiologist (A1), who conducted anaesthesia, performed the allocated intervention, and did the intraoperative monitoring. The observer (A2) recording the parameters and visual analogue scale (VAS) scores were blinded to the allocation and intervention performed. The study was double-blinded, as the patient was also blinded to the allocation and intervention performed.

Complete pre-anaesthetic check-ups (PAC) and optimisation were done before patient scheduling. Investigations such as 12 lead electrocardiogram, 2D echocardiography, complete blood counts, kidney function test, liver function test, serum electrolytes, coagulation parameters, and viral markers as per hospital surgical protocol were advised and checked.

Patients were on empty stomachs for 6 hours for solids and clear fluids at least 2 hours before surgery. Premedication, as per the institutional protocol, was oral alprazolam 0.25 mg administered the previous night of surgery, oral paracetamol 650 mg, and oral esomeprazole 40 mg with domperidone 10 mg administered in the morning with sips of water.

After reconfirming consent in the OR, an 18-G intravenous (IV) cannula was established, and balanced salt solution intravenous fluid was started at 2 mL/kg/h. In the OR, after attachment of all standard monitors, such as non-invasive blood pressure (NIBP), electrocardiogram (ECG), and pulse oximetry (SpO_2), spinal anaesthesia (sub-arachnoid block) was given using 25-G Quincke-Babcock spinal needle, with 3.4 cc of 0.5% levobupivacaine (with dextrose), in sitting position. After the desired effect was checked in the supine position, IV dexamethasone 8 mg was given prophylactically for postoperative nausea and vomiting (PONV), and an IV midazolam 1.5 mg for sedation. Then, a guided nerve block was performed as per the protocol. A standard mixture of 25 mL 0.2% ropivacaine and 50 μg of dexmedetomidine (maximum 1 μg/kg) was used for the intervention. Time to performance of block from needle insertion to removal, after successful completion of the block, was noted by an observing OR technician using a mobile phone stopwatch.

Group A – for the iPACK block: The patient was supine, with the knee flexed slightly and the limb externally rotated. A low-frequency curvilinear probe was used to identify the medial femoral condyle. The popliteal artery was identified over the femoral shaft while scanning proximally. At this point, the needle was inserted in-plane medially to laterally, flush to the posterior border of the femur, till the tip was visualised between the bone and artery. At this point, 10 mL of the mixture was injected, and another 5 mL was infiltrated while slowly removing the needle flush to the femoral shaft.[6-8] For ACB, a linear high-frequency probe was placed at mid-thigh, sartorius and superficial femoral artery (SFA) was identified, and laterally saphenous nerve was identified. Lateral-to-medial in-plane needle insertion was done towards SFA, and 10 mL of the drug mixture was injected, perivascular after negative aspiration.

Group B – for 4-in-1 block: The patient was in a supine frog-leg position (external rotation, slight abduction, and knees slightly flexed). Using a linear high-frequency probe, the medial femoral condyle was identified, sliding proximally from the condyle, and the intersection of vastus medialis and sartorius muscles was identified. Then, proximal to the adductor hiatus, the SFA was identified. The injection was done by moving the probe proximal to visualise the descending genicular artery, just 1 cm proximal to this branching. The needle was inserted to reach the perivascular space in the in-plane from lateral to medial. With a repeated negative aspiration for blood, 25 mL of the drug mixture was injected to push the femoral artery posteriorly with every 2 mL aliquot of injection.[15,16]

The surgery was performed as scheduled and as per surgical protocol. Intraoperative data recorded were haemodynamic parameters, the block performance time (starting from needle insertion to removal), and the duration of surgery. Postoperatively, multi-modal analgesia was provided by IV paracetamol 1000 mg every 8 hours, IV tramadol 25 mg every 8 hours, and IV diclofenac 75 mg diluted in 100 mL normal saline every 12 hours. IV tramadol 50 mg diluted in 100 mL normal saline, when VAS score ≥ 4, was advised for rescue analgesia. The primary outcome measures of assessing postoperative analgesia, using VAS, were noted at 3, 6, 12, 24, and 36 hours. The secondary outcome measures of rescue analgesic requirement were noted at the same intervals, based on VAS. 4. The duration of spinal anaesthesia motor blockade was assessed using the Bromage score.[17] Lower limb motor weakness due to nerve block was examined using the 4P acronym method,[18] assessing the push, pull, and punt for the sciatic nerve. Femoral nerve assessment was done at the same intervals to determine the impact of interventions on length of stay.

The protocol for complications, if any, was defined—for example, in case of an inadvertent vascular puncture, the block was to be abandoned, with immediate compression of the injection site for 10 minutes. The study participant was to be observed closely for 24–48 hours for any other vascular complications and dropped out of the study.

Sample size calculation was done using OpenEpi.com, Version 3, an open-source calculator, using mean VAS at 24 hours [Group M – 1.45 [(Standard deviation (SD): 1.09) and Group I – 1.88 (SD: 0.9)) from a study done by Roy *et al*.,[16] with a 95% confidence interval (CI) and power at 80%, a minimum of 172 participants (86 in each group) were needed, to achieve the effective

objective of comparing the analgesia of the studied interventions. We studied 184 patients (92 in each group), considering a 5% inadvertent dropout. Statistical Package for the Social Sciences (SPSS) statistics software version 25.0 (International Business Machines Corporation (IBM Corp), Armonk, NY, USA) was used for statistical analysis. Mean (SD) was used for continuous or quantitative variables, such as age, weight, duration of surgery, time to perform the block, duration of motor block, time to rescue analgesics, and VAS scores, and frequency was used to denote categorical variables, such as gender and ASA physical status. The association of quantitative variables, such as age, weight, duration of surgery, time to perform the block, duration of motor block, time to rescue analgesics, and VAS scores amongst groups, was analysed with an independent sample *t*-test. Similarly, the association of categorical variables, such as gender and ASA physical status, was done using a Chi-square test. Statistical significance was considered with a *P* value of <0.05.

RESULTS

In total, 184 patients were assessed for inclusion in the study and randomised; two were lost to follow-up during the study, and 90 patients in group A and 92 in group B were included [Figure 1]. The demographic characters (age, gender, and weight), ASA class, and surgery duration were statistically similar in the two groups ($P > 0.05$) [Table 1]. Pain scores measured using VAS score were comparable between the two groups at 3, 6, and 12 hours ($P = 0.089$) and 24 hours ($P = 0.083$) but were less at 36 hours in group B ($P < 0.05$) [Table 2]; 9.34% of the patients required rescue analgesia earlier in group A ($P = 0.036$) [Table 2].

The time to perform the regional block was lower in group B, a single injection technique ($P < 0.001$). The duration of the motor block was similar statistically ($P = 0.325$). The duration of the hospital stay was statistically similar ($P =$ cannot be computed) [Table 2]. None of the patients showed motor weakness due to nerve block techniques. They could cooperate reasonably with physiotherapy on day one postoperatively as per surgical protocol and were discharged on day 2, with similar LOS in either group.

Table 1: Comparative demographic data of the study population

	Group A (*n*=90)	Group B (*n*=92)
Age (in years), mean (SD)	29.13 (8.72)	31.54 (7.86)
Gender (females/males) (*n*)	22/68	14/78
Weight (in kg), mean (SD)	70.04 (7.81)	70.82 (9.02)
American Society of Anesthesiologists physical Status (I/II) (*n*)	87/3	84/8
Duration of surgery (in hours), mean (SD)	1.87 (0.25)	1.82 (0.24)

SD=Standard deviation, n=number of patients

DISCUSSION

This study found comparable VAS scores in 4-in-1 and iPACK plus ACB groups, confirming our hypothesis that postoperative analgesia provided by the 4-in-1 block is non-inferior to the combination of iPACK with ACB for ACL repair.

The findings were similar to those of Roy *et al.*,[16] who compared the interventions for analgesia post knee arthroplasty. The time to perform the 4-in-1 block was significantly lower than the combination of iPACK plus ACB, while the interventions did not interfere with or delay the postoperative physiotherapy and discharge. The study by Srinivasan *et al.*[19] supports our findings that the 4-in-1 block is logistically easier to perform with the least side effects. Furthermore, 9.34% of study participants required to recuse analgesia, of whom the requirement was significantly earlier in iPACK plus ACB groups, along with a typical finding of VAS lower in the 4-in-1 group at 36 hours, which could be due to higher volume at a single injection point.

Previous studies and meta-analyses reiterate that iPACK block provides posterior knee analgesia, and combining iPACK with ACB provides adequate analgesia, even on ambulation, with ipsilateral graft harvesting.[10-14] Based on these studies, we can say that the combination of iPACK and ACB is the superior analgesia of choice for arthroscopic ACL surgery.

The basis of the drug spread of 4-in-1 block is supported by a cadaveric study done by Runge *et al.*[20], in which a 10 mL dye in the distal adductor canal spreads to nerves such as the saphenous, medialis vastus, popliteal plexus, and posterior division of the obturator.

The major limitations of this study were the lack of motor blockade assessment, which requires multiple tools for a completely objective assessment, and detailed VAS assessment at rest and on movement, which could have validated the effect of the interventions studied. Interventions such as 4-in-1 block also need minimum

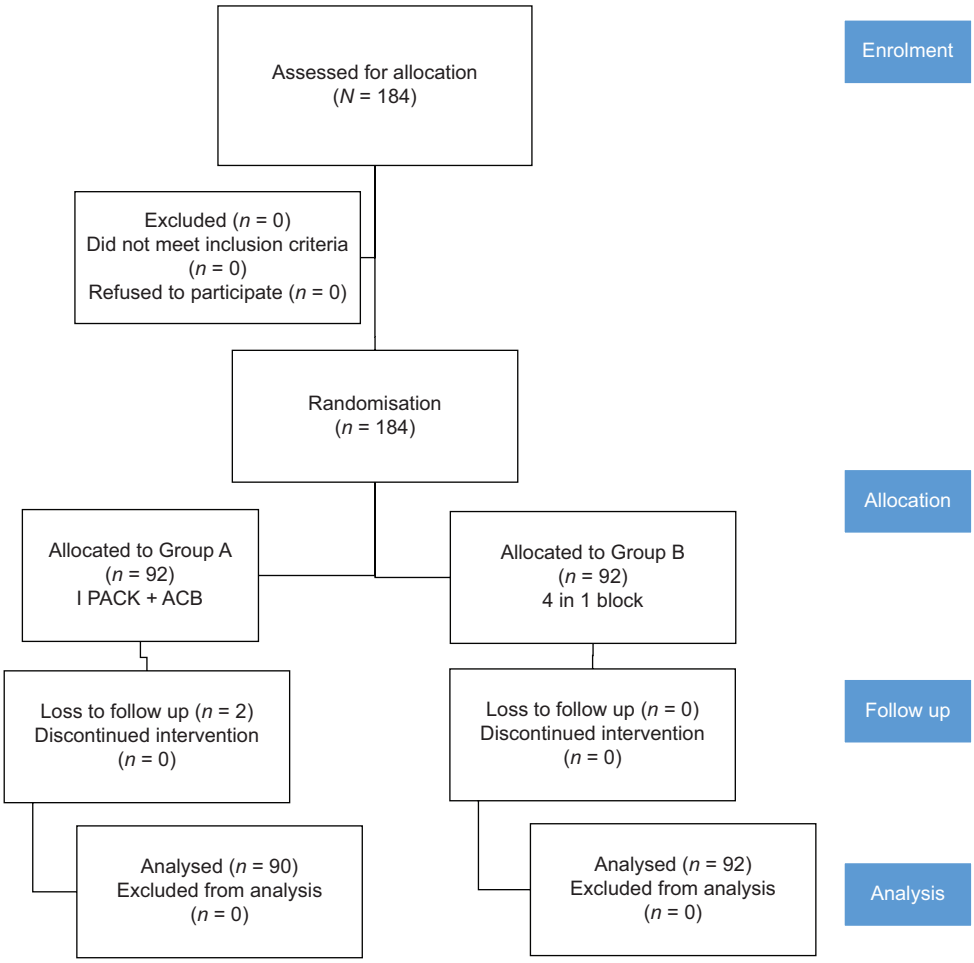

Figure 1: Consolidated Standards of Reporting Trials (CONSORT) flow diagram for participant enrolment

Table 2: Comparison of study parameters among the groups

	Group A (*n*=90)	Group B (*n*=92)	Mean difference (95% Confidence Interval)	*P*
VAS: 3 hours, mean (SD)	0 (0)	0 (0)	-	-
VAS: 6 hours, mean (SD)	0 (0)	0 (0)	-	-
VAS: 12 hours, mean (SD)	0.13 (0.50)	0.30 (0.81)	−1.71 (−0.37, 0.03)	0.089
VAS: 24 hours, mean (SD)	2.20 (1.16)	1.86 (1.46)	0.341 (−0.04, 0.78)	0.083
VAS: 36 hours, mean (SD)	3.99 (0.68)	3.51 (1.01)	0.48 (0.23, 0.73)	<0.001
Time to perform block (in minutes), mean (SD)	5.22 (0.60)	2.93 (0.44)	2.287 (2.13, 2.44)	<0.001
Duration of motor block (in hours), mean (SD)	4.49 (0.95)	4.34 (1.12)	0.152 (-0.15, 0.46)	0.325
Rescue analgesia required/not required (*n*)	9/81	8/84	-	0.762
Time to rescue analgesic (in hours), mean (SD)	22.33 (14.91)	35.00 (4.41)	−12.667 (−24.34, −0.97)	0.036
Duration of hospital stay (days), mean (SD)	2.00 (0.00)	2.00 (0.00)	-	-

SD=Standard deviation, VAS=Visual analogue scale, *n*=number of patients

effective volume determination for comparable effectiveness. Hence, extensive studies are required to validate the findings regarding early rehabilitation. The safety of the technique also needs to be assessed and validated.

CONCLUSION

The 4-in-1 block provides non-inferior analgesia compared to the established iPACK plus adductor canal blocks for arthroscopic knee surgery.

Study data availability

De-identified data may be requested with reasonable justification from the authors (email to the corresponding author) and shall be shared after approval as per the authors' Institution policy.

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Conflicts of interest

There are no conflicts of interest.

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REFERENCES

1. Maheshwer B, Knapik DM, Polce EM, Verma NN, LaPrade RF, Chahla J. Contribution of multimodal analgesia to postoperative pain outcomes immediately after primary anterior cruciate ligament reconstruction: A systematic review and meta-analysis of level 1 randomized clinical trials. Am J Sports Med 2021;49:3132–44.
2. Yin X, Li X, Zhao P. Comparison of adductor canal block and femoral nerve block for pain management in anterior cruciate ligament reconstruction: A meta-analysis of randomised controlled trials. Medicine 2022;101:e29295. doi: 10.1097/MD.0000000000029295
3. Seo SS, Kim OG, Seo JH, Kim DH, Kim YG, Park BY. Comparison of the effect of continuous femoral nerve block and adductor canal block after primary total knee arthroplasty. Clin Orthop Surg 2017;9:303–9.
4. Li J, Ma Y, Xiao L. Postoperative pain management in total knee arthroplasty. Orthop Surg 2019;11:755–61.
5. Thobhani S, Scalercio L, Elliott CE, Nossaman BD, Thomas LC, Yuratich D, *et al*. Novel regional techniques for total knee arthroplasty promote reduced hospital length of stay: An analysis of 106 patients. Ochsner J 2017;17:233–8.
6. Jung DW, Shon WY, Seo SS, Kim OG, Lee IS. Comparison of the postoperative analgesic effect for infiltration between the popliteal artery and the capsule of the posterior knee and that of periarticular multimodal drug injection in total knee arthroplasty: Retrospective study in the immediate postoperative period. Knee Surg Relat Res 2020;32:1. doi: 10.1186/s43019-019-0025-z
7. Ochroch J, Qi V, Badiola I, Grosh T, Cai L, Graff V, *et al*. Analgesic efficacy of adding the IPACK block to a multimodal analgesia protocol for primary total knee arthroplasty. Reg Anesth Pain Med 2020;45:799–804.
8. Kandarian B, Indelli PF, Sinha S, Hunter OO, Wang RR, Kim TE, *et al*. Implementation of the IPACK (Infiltration between the Popliteal Artery and Capsule of the Knee) block into a multimodal analgesic pathway for total knee replacement. Korean J Anesthesiol 2019;72:238–44.
9. Kertkiatkachorn W, Kampitak W, Tanavalee A, Ngarmukos S. Adductor canal block combined with iPACK (Interspace between the popliteal artery and the capsule of the posterior knee) block vs periarticular injection for analgesia after total knee arthroplasty: A randomized noninferiority trial. J Arthroplasty 2021;36:122-9.e1. doi: 10.1016/j.arth.2020.06.086
10. Patterson ME, Vitter J, Bland K, Nossaman BD, Thomas LC, Chimento GF. The effect of the IPACK block on pain after primary TKA: A double-blinded, prospective, randomized trial. J Arthroplasty 2020;35:S173–7.
11. Amin MAA, Abotaleb UI. Value of IPACK block (interspace between the popliteal artery and the capsule of the posterior knee) with adductor canal block in total knee arthroplasty. Al-Azhar Int Med J 2021;2:13–8.
12. Mahmoud A, Boules M, Botros J, Mostafa M, Ragab S, Alsaeid M. Analgesic impact of a popliteal plexus block to standard adductor canal block in arthroscopic anterior cruciate ligament reconstruction: A randomized blind clinical trial. Pain Res Manag 2021;2021:1723471. doi: 10.1155/2021/1723471
13. Vijay M. Comparing continuous adductor canal block alone, with combined continuous adductor canal block with iPACK in terms of early recovery and ambulation in patients undergoing unilateral total knee replacement- A prospective randomized double blinded study. J Evid Based Med Healthc 2020;7:47–51.
14. Albrecht E, Wegrzyn J, Dabetic A, El-Boghdadly K. The analgesic efficacy of iPACK after knee surgery: A systematic review and meta-analysis with trial sequential analysis. J Clin Anesth 2021;72:110305. doi: 10.1016/j.jclinane.2021.110305
15. Roy R, Agarwal G, Pradhan C, Kuanardr D, Mallick DJ. Ultrasound-guided 4 in 1 block – A newer, single injection technique for complete postoperative analgesia for knee and below knee surgeries. Anaesth Pain Intensive Care 2018;22:87–93.
16. Roy R, Agarwal G, Latwal BS, Patel A, Mohta A. A comparative randomized controlled study of modified 4 in 1 block versus IPACK plus adductor canal block for postoperative analgesia in total knee arthroplasty. Indian J Anaesth 2023;67:296–301.
17. Craig D, Carli F. Bromage motor blockade score – a score that has lasted more than a lifetime. Can J Anesth 2018;65:837–8.
18. Neal JM. Assessment of lower extremity nerve block. Reg Anesth Pain Med 2002;27:618–20.
19. Srinivasan P, Dagupatti H, Saravanan B. Ultrasound guided 4 in 1 block for managing postoperative pain in arthroscopic knee surgery. Sri Lankan J Anaesthesiol 2019;27:86-8.
20. Runge C, Moriggl B, Børglum J, Bendtsen TF. The spread of ultrasound-guided injectate from the adductor canal to the genicular branch of the posterior obturator nerve and the popliteal plexus: A cadaveric study. Reg Anesth Pain Med 2017;42:725–30.