

# Interspace between the Popliteal Artery and the Capsule of the Knee (IPACK) Block for Anterior Cruciate Ligament Reconstruction Surgery: A Two Case Series

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## Abstract

This case series describes the use of Interspace between the Popliteal Artery and the Capsule of the Knee (IPACK) block to provide motor-sparing analgesia for two consecutive patients undergoing anterior cruciate ligament reconstruction (ACLR) by the same surgeon. Case 1 demonstrates the use of a proximal IPACK block as a post-operative rescue block for a patient who still experienced severe pain despite having received a femoral nerve block and parenteral opioids. Case 2 describes the use of a modified IPACK block as part of a multimodal approach with opioid and motor sparing effects. In both cases, the IPACK block provided satisfactory pain relief in the immediate postoperative period without motor weakness, making it an effective analgesic method for day surgery. With the IPACK block shown to be an effective nerve block for ACLR, we explore other advantages, limitations and further research required to better define the role of this block.

## Keywords

IPACK, Anterior Cruciate Ligament Reconstruction

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## 1. Introduction

Anterior cruciate ligament reconstruction (ACLR) surgery is associated with moderate to severe postoperative pain which can be attributed to both arthroscopic surgery and the graft donor site [1]. A multimodal analgesia regime with peripheral nerve blocks (PNB) is therefore recommended for this procedure [2]. There are various choices of PNBs available either as a single injection or in combination. Given the multiple innervations of the knee, complete pain relief

would not be expected from either the femoral nerve block (FNB) or the saphenous nerve block [3] [4] alone.

The recent technique of ultrasound guided local anesthetic infiltration of the interspace between the popliteal artery and the capsule of posterior knee (IPACK) has shown promising results [3] [5] [6]. The technique involves a very selective block of the terminal sensory branches of the posterior aspect of the knee without the involvement of motor branches of the tibial and peroneal nerves leading to reduced pain without motor weakness [7] [8]. This leads to earlier ambulation, rehabilitation and recovery in various knee surgeries [6].

The IPACK block has evolved from being performed in a prone position where the injection occurs at the popliteal crease at the level of the femoral condyles, to being done with the patient supine. In the supine position, the transducer is placed in the medial lower third aspect of the thigh to observe the femoral artery under the sartorius muscle. The transducer is then slid caudally to trace the artery as it dives into the popliteal fossa through the adductor hiatus to become the popliteal artery [3] [7] [8] [9] [10]. We aim to block the popliteal plexus, saphenous nerve and nerve to vastus medialis with a single injection by redirecting the needle after a single puncture. This avoids multiple injections sites.

We describe our experience with the proximal approach of the IPACK block for ACLR.

These 2 patients were selected as they were under the care of the same surgeon and anesthetist. The IPACK block was offered to reduce pain, opioid consumption and facilitate early rehabilitation and discharge.

## 2. Case Presentation

Written informed consent was provided by all patients for inclusion in this report.

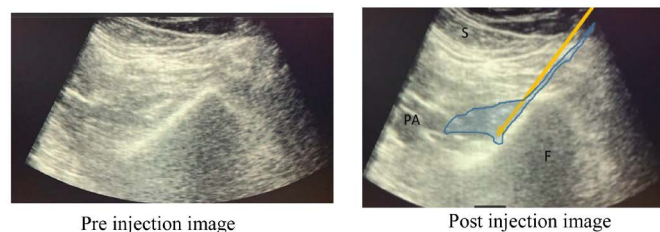
### 2.1. Case 1

We present a 29 year old ASA physical status 1 male (186 cm, 110 Kg, BMI 32), with allergy to non-steroidal anti-inflammatory drugs, who underwent a left knee ACLR with hamstring autograft, medial meniscus repair and extra-articular tenodesis. He received oral paracetamol 1 g one hour prior to surgery for preemptive analgesia. A femoral nerve block was performed preoperatively under ultrasound guidance with 15 ml of 0.5% Ropivacaine as per our hospital pathway. He received a general anesthetic (GA) with a supraglottic airway for the surgery. GA was maintained with nitrous oxide and desflurane. Intraoperative analgesia comprised of fentanyl 100 mcg, ketamine 50 mg and oxycodone 10 mg. Surgery duration was 80 minutes. The patient had a pain score of 7/10 over the posterior knee 1 hour after the end of surgery whilst in the post anesthesia care unit (PACU). The IPACK block was hence offered. As the knee was bandaged, we used the proximal approach to avoid the surgical dressing. Under ultrasound guidance using the curvilinear probe, we traced the femoral artery caudally beginning under the sartorius muscle to where it dives deep at the adductor hiatus. A 150 mm 21 gauge needle (Stimuplex, B. Braun) was inserted in an anteromedial-posterolateral di-

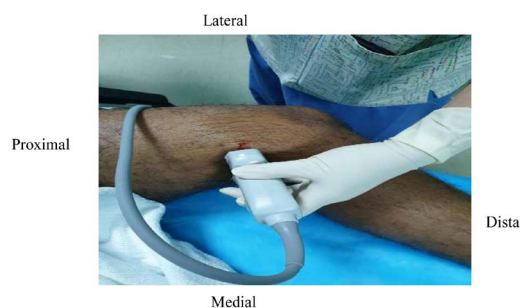
rejection to the space between the popliteal artery and the femoral shaft. The needle was advanced 1 - 2 cm lateral to the popliteal artery in close proximity to the femoral shaft. After negative aspiration, 25 ml of 0.5% Ropivacaine was injected as the needle was gradually withdrawn. Ultrasound scan confirmed that the local anesthetic agent did not spread to the sciatic nerve (**Figure 1**). His pain score decreased to 0/10 within 5 minutes of the block. Plantar flexion and extension of bilateral feet were tested to be equal and full.

## 2.2. Case 2

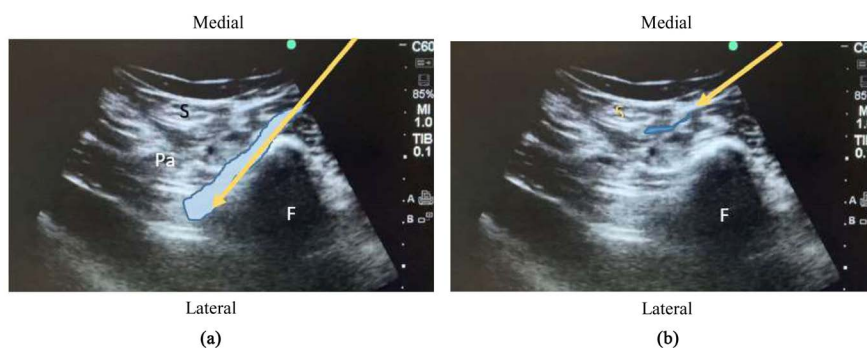
A 25 year old ASA physical status 1 male (173 cm, 73 kg, BMI 24) who underwent a left knee ACLR with hamstring autograft and lateral meniscus repair. He received oral paracetamol 1 g and etoricoxib 120 mg 1 hour prior to surgery for preemptive analgesia. He was offered a modified IPACK block and adductor canal block which were performed pre-operatively. The patient was placed in a supine position with the left leg externally rotated and flexed (**Figure 2**). The proximal IPACK block was performed as described above with 15 ml of 0.5% Ropivacaine given as the needle was withdrawn (**Figure 3(a)**). The needle is then re-directed to deposit 10 mls of Ropivacaine under the Sartorius muscle (**Figure 3(b)**). General Anaesthesia with a supraglottic airway device was then induced and maintained with nitrous oxide and desflurane. Intraoperative analgesia consisted of fentanyl 100 mcg and ketamine 25 mg. Surgery duration was 50 minutes. Immediate post-operative pain scores were 0/10 at rest and 1/10 on movement. He did not require any opioids in the post-operative period. Patient was able to elevate his operated leg and perform plantar and dorsiflexion in the post anesthesia care unit (**Table 1**).



**Figure 1.** Ultrasound scan of IPACK block with spread of local anaesthetic. S = Sartorius muscle, F = Femoral shaft, PA = Popliteal artery.



**Figure 2.** Patient position of the left leg with slight external rotation and knee flexion and ultrasound probe placement during IPACK block.



**Figure 3.** F = Femur, S = Sartorius muscle, Pa = Popliteal artery. Arrows indicate direction of needle with LA (blue area) deposits.

**Table 1.** Summarizes the patient characteristics of the 2 patients.

	Case 1	Case 2
Age (years)	29	25
Gender	Male	Male
Race	Chinese	Chinese
BMI	32	24
ASA Physical Status	1	1
Anesthesia Technique	GA with LMA	GA with LMA
Surgery Duration (min)	80	50
Pre operative analgesia	Paracetamol 1 g	Paracetamol 1 g Etoricoxib 120 mg
Intra operative Analgesia used	Fentanyl 100 mcg Oxycodone 10 mg Ketamine 25 mg	Fentanyl 100 mcg Ketamine 25 mg
Nerve block performed preoperatively	Femoral Nerve block	Modified IPACK block and adductor canal block
IPACK Block performed	Rescue block 1 h post operatively	Preemptive analgesia done preoperatively
Pain score 1 hour post op		
- At rest	7	0
- on movement	10	1
- 5 min after rescue block	0	-
Complications	Nil	Nil

### 3. Discussion

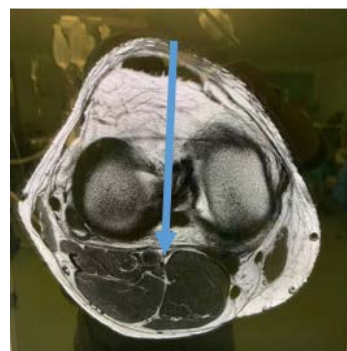
Multimodal analgesia consisting of two or more modalities is recommended for ACL reconstruction surgeries to reduce opioid consumption and shorten hospital stay [11] [12] [13] [14]. A repertoire of regional anesthesia options includes epidural [15], lumbar plexus block [16] [17], psoas compartment block [18], femoral nerve block (FNB) [19], adductor canal block [20] and sciatic nerve block [16] [21] [22]. More recently, addition of the obturator nerve block to the ad-

ductor canal block has been recommended [23]. There have been systematic reviews for Local Infiltration techniques [24]. Regional techniques have evolved from the more invasive central neuraxial and deep compartment blocks to equally effective peripheral techniques with reduced risks and motor blockade. Whilst some of the peripheral nerve blocks are less risky and easier to perform, a combination of two or three blocks [16] [25] may be needed to provide complete analgesia for the knee making them uncomfortable for the patient. Potential motor blockade makes these combination PNBs unsuitable for day surgery.

There has been a move towards finding a more suitable analgesic option that does not impair motor function such as local infiltration of analgesia (LIA) by surgeons, as first described by Kerr [26]. However, the infiltration is performed blind by the surgeon into the posterior capsule and risks blocking the sciatic and common peroneal nerve (Figure 4). There is a wide variation in content, volume and sites performed by the surgeon with thus variable analgesic effect.

IPACK block is an alternative to provide analgesia to the posterior aspect of the knee with less risk of motor blockade. This is accomplished by blocking the articular branches of the obturator, common peroneal (CPN) and tibial nerves within the popliteal fossa [3] [7] [8]. As this technique is performed under ultrasound guidance, the possibility of blocking the sciatic nerve or CPN is reduced. Table 2 summarizes the advantages and disadvantages of the IPACK block in comparison with other commonly performed blocks.

There have been cadaveric studies to observe the spread of dye with various approaches and differing volumes [7] [8] [10] to understand the potential nerves blocked in the IPACK block. The ideal level and volume of injectate has yet to be determined. There are postulations that the popliteal plexus (end articular nerves) may be blocked with 15 mls of local anaesthesia given in the caudal end of the adductor canal [8] [25]. The dye is shown in cadaveric studies to spread via the adductor hiatus into the popliteal region [8]. A single injection at the distal adductor canal may be able to block both the saphenous nerve and the popliteal plexus within the popliteal fossa. Clinical studies will need to be conducted to determine the ideal approach, volume and if combination with other PNBs has added analgesic benefit [10] [11] [25].



**Figure 4.** MRI image cross section of knee showing the close proximity of the neurovascular bundle to the posterior capsule. Arrow indicates direction of LIA.

**Table 2.** Comparison of the IPACK block and other commonly performed blocks.

	IPACK	LIA	Femoral Nerve Block	Adductor Canal block	Sciatic Nerve Block
Usual volume of LA (mls)	15	150	10 - 15	10 - 20	10 - 25
Nerves covered	Terminal sensory branches of obturator, CPN and tibial nerves	Local & systemic effects	Femoral nerve	Saphenous nerve	Posterior Tibial nerve at popliteal fossa
Advantages	Safer blocks than central neuraxial blocks especially in patients with coagulopathy or patients on antiplatelet agents.				
	<ul style="list-style-type: none"> <li>1) Localised to periarticular region with sparing of vastus muscles;</li> <li>2) Minimal weakness thus facilitates early rehabilitation;</li> <li>3) Relatively easy to perform with lower risk of nerve injury;</li> <li>4) Potential of covering saphenous nerve.</li> </ul>	<ul style="list-style-type: none"> <li>1) Performed by surgeon and thus less concern of graft infection;</li> <li>2) Studies have shown that it works as well as Femoral nerve block;</li> <li>3) Do not require additional ultrasound machine/trained anaesthetist.</li> </ul>	<ul style="list-style-type: none"> <li>1) Simple and superficial block that can be performed by most anaesthetist;</li> <li>2) Proven to have opioid sparing and pain scores in knee procedures [2].</li> </ul>	<ul style="list-style-type: none"> <li>1) Simple and superficial block that can be performed by most anaesthetists;</li> <li>2) Avoids blockade of the vastus lateralis and vastus intermedius with less impairment of hip flexion.</li> </ul>	<ul style="list-style-type: none"> <li>1) Definitive coverage of the posterior knee;</li> <li>2) Relatively easy to perform.</li> </ul>
Disadvantages	<ul style="list-style-type: none"> <li>1) Relatively deep block compared to the other peripheral nerve blocks;</li> <li>2) LA spread may affect sciatic nerve with potential of motor blockade;</li> <li>3) Performed near surgical site hence risk of surgical site contamination;</li> <li>4) New technique with few studies;</li> <li>5) Few anaesthetists performs the technique;</li> <li>6) Ideal approach and volume yet to be determined.</li> </ul>	<ul style="list-style-type: none"> <li>1) Large volume required with risk of LA toxicity;</li> <li>2) Variability in technique, volume and concoction by various surgeons;</li> <li>3) Not pre-emptive and hence risk of wind up phenomenon.</li> </ul>	<ul style="list-style-type: none"> <li>1) Results in motor blockade with risk of fall and delayed rehabilitation;</li> <li>2) Has not been found to be more advantageous than multimodal analgesia [2];</li> <li>3) Does not cover posterior aspect of the knee.</li> </ul>	<ul style="list-style-type: none"> <li>1) Blocked performed at site of tourniquet may increase the risk of nerve injury (direct pressure, LA axonal toxicity and needle penetration);</li> <li>2) May still block the branches to the Vastus medialis if large volume is given;</li> <li>3) The Adductor canal or sub Sartorius definition is still controversial.</li> </ul>	<ul style="list-style-type: none"> <li>1)Foot drop may occur if the common peroneal nerve is blocked;</li> <li>2) May delay rehabilitation and discharge;</li> <li>3) Does not cover anterior aspect of the knee.</li> </ul>

The second case may support this theory that the adductor canal and the popliteal area is connected. Tran et al found that the dye injected from a medial IPACK approach tracked into the adductor canal and Runge et al found that dye injected in the adductor canal tracks in the popliteal area [7] [8]. If the nerve to the vastus medialis can be blocked with this same injection, it would avoid having to do a second block at the femoral triangle [27] or adductor canal [6] [11]. In their feasibility study by Runge *et al.*, their needle was directed from the vastus medialis toward the femoral artery as it exits the adductor hiatus with the local anaesthetic deposited near the artery [25]. In our second case, we directed our needle more proximally, under the sartorius muscle, similar to a sub-sartorial adductor canal approach. The patient had good analgesia and opioid sparing effect with no significant motor blockade. This would make the IPACK block an ideal preemptive analgesic technique for day surgery as it can be added to a non-opioid multimodal analgesia pathway [2].

However, the clinical analgesia provided by modification of this IPACK block needs further studies to determine the optimal volume and dose of local anesthetic at the various injection sites. The injection at the adductor canal may be preferred as it is further from the surgical site allowing for catheter placement and reduced risk of surgical site contamination.

#### 4. Conclusion

Our case series demonstrates the use of proximal IPACK block for ACLR surgeries as a useful analgesic option which is safe, effective and easy to perform. There was also significant opioid sparing effect with reduced risk of motor blockade. As the IPACK block is still evolving, further randomized controlled studies are required to determine the optimal site, volume and dose of LA required to achieve the desired clinical results; and to assess the safety and efficacy of this technique against other blocks.

#### Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

#### Consent for Publication

Informed consent was obtained for all patients.

#### Authors' Contribution

KLW and AH recruited, consented and managed the patients.

AH, KLW and PAS wrote the manuscript.

All authors read and approved the manuscript.

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### **List of Abbreviations**

IPACK: Interspace between the Popliteal Artery and Capsule of the Knee

ACLR: Anterior Cruciate Ligament Reconstruction

PNB: Peripheral Nerve Block

FNB: Femoral Nerve Block

ASA: American Society of Anaesthesia

BMI: Body Mass Index

GA: General Anaesthesia

LMA: Laryngeal Mask Airway

PACU: Post Anaesthesia Care Unit