

Analgesic Techniques after Total Knee Arthroplasty

May Essam Abdelmonem, Ahmed Abdel hakim Balata, Hala Ibrahim Zanfaly, Amira said Elsayed

Department of Anesthesia, Intensive Care & pain management, Faculty of Medicine, Zagazig University, Egypt

Corresponding author: May Essam Abdelmonem

E-mail: mayessam021@gmail.com, mayessam@medicine.zu.edu.eg

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Abstract

Background: In order to give patients early relief and pain-free postoperative care, managing pain after knee surgery has become a challenging task. Postoperative analgesic treatment primarily aims to lessen the need for opioids, alleviate pain after surgery, and prevent complications associated with opioid use. Methods for managing pain following total knee arthroplasty (TKA) surgery were the focus of this narrative evaluation. Although opioids are powerful analgesics, the traditional method has relied on high-dose opioid regimens, which have a number of undesirable side effects that have prompted researchers to look for alternatives. It is questionable if sciatic nerve blocks contribute to post-TAS pain. Although Femoral Nerve Block (FNB) is currently the gold standard, it comes with risks such as quadriceps weakness, fall risk, and sciatic block, which can cause foot drop. These limitations have led to the development of further distal nerve block procedures, such as selective tibial and saphenous nerve blocks in the adductor canal, which promise analgesia on par with that of femoral and sciatic nerve blocks. In order to minimize the side effects of traditional opioid-based analgesia, speed up functional recovery, increase patient satisfaction, and reduce overall length of hospitalization and cost, it is essential to combine pre-emptive and multi-modal analgesia with technically well-delivered regional nerve blocks and postoperative physical therapy.

Keywords: Analgesic techniques, Total Knee Arthroplasty

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Introduction:

Joint replacement surgeries are considered as one of the most painful orthopaedic procedures. This painful procedure is the result of inadequate and poorly treated postoperative pain after major joint replacement surgery. This pain episode must be timely addressed because not only does this significantly prolong the rehabilitation process, but also causes the increased risk of other complications. If not addressed within time or without proper approach, these postoperative painful episodes can progress into chronic pain, which eventually prolongs the overall length of hospitalization and cost.[1] The journey to achieve the complete and long-term pain relief begins before the surgery is performed. An important basis to achieve long-term pain relief and functional

recovery after the joint surgery involves sufficient peri-operative analgesia.[2] One of the important aspects to achieve successful outcome after joint surgery is the early joint mobilization with the initiation of physical therapy.[3] Several new drugs and novel techniques to ameliorate the post-operative pain post-surgery are being introduced every year, but most of the patients still end up suffering from extreme pain immediately after surgery which often progresses into chronic pain.[4]

Arthroscopic knee surgery has become increasingly popular in modern orthopaedics.[5,6] Still, the post-operative knee pain management involving early relief and pain-free postoperative care to the patient remains a challenge to several clinicians.[7,8] In some cases, pain management in itself has become a priority for management as a daycare procedure. Persistent pain after knee arthroplasty remains an unresolved issue for many patients.[9,10] Pain is considered as a very subjective event because everyone has a different perception and threshold of pain.[11] And therefore, it becomes very difficult to standardize any pain regime for a particular surgery. Several factors that cause knee pain, which include irritation of free nerve endings of the joint capsule, synovial tissue, anterior fat pad.[12,13]

Adding to these, the post-operative pain levels are also influenced by the preoperative pain levels of the patient.[15] It is important to remember that adequate analgesia affects the overall hospital stay and early rehabilitation of the patient after surgery.[16,17] The conventional techniques of pain alleviation after total joint replacement included a heavy reliance on the opioid, oral or intravenous (IV), patient-controlled analgesia (PCA) with IV opioid or epidural infusion.[18] Opioid is considered as a strong analgesic, but they are linked with several unwanted side effects like vomiting, nausea, delay ambulation, constipation, sedation, respiratory depression, and pruritus.[19,20] Continuous epidural and PCA limits patient ambulation requires close monitoring and frequent dose adjustment and may not be appropriate for all patients.[21,22] Studies have found out that a single dose regime might be unsuitable for every patient in PCA. All these conditions often lead to under dosing or overdosing with troublesome side effects.[23,24] The increased understanding of pain patho-physiology, pharmacology of analgesics and their limitations have led the researchers to find alternative approaches for pain management. These novel approaches to target the pain management at different levels that support each other with minimal side effects. The aim of the current review article is to provide concisely and up to date information on the available analgesics modalities after total knee arthroplasty, which is important for both safety and effectiveness for most patients. Optimal postoperative analgesia after total knee arthroplasty is the key for earlier recovery and functional outcomes.

1. Pre-emptive analgesia

Preemptive analgesia, an antinociceptive treatment, is the treatment which is initiated prior to the surgery so that the pain sensitization evoked by the incision-related and inflammatory injuries occurring during surgery can be prevented. Along with conducting before the surgery, Pre-Emptive analgesia can be utilized in the early postoperative period.[25,26] This protective effect is provided by pre-emptive analgesia on the nociceptive system. In order to block the pain sensation, literature has recorded several approaches including drugs and routes:

1a. Parenteral and oral nonsteroidal anti-inflammatory drugs (NSAIDs): Nonsteroidal anti-inflammatory drugs (NSAIDs) involve a category of drugs that have chiefly the analgesic and antipyretic actions.[27] Majority of NSAIDs serve as non-selective inhibitors of the enzyme

cyclooxygenase (COX). Further, they also reversibly inhibit both the isoenzymes (COX-1 and COX-2).[28] COX enzyme catalyzes the formation of thromboxane and prostaglandins from arachidonic acid. These released prostaglandins then serve as the messenger molecules in the inflammation pathway.[29]

1b. Sublingual and intravenous (IV) opioids: Opioids are known to produce profound and prolong analgesia. This positive role in pre-emptive analgesia is due to the interaction of opioids with various opioid receptors that ultimately produce analgesia.[30,31] The study carried out by Campiglia *et al.*, report that in patients who underwent elective abdominal surgery, the pre-medication with sublingual morphine sulfate resulted in superior control of postoperative pain, when compared to pre-medication with sublingual midazolam.[32]

1c. Local anesthetics (LA): Local anesthetics are the membrane-stabilizing drugs. They act primarily by hampering sodium influx through voltage-gated sodium channels. This hamper mechanism thereby inhibits the generation of the action potential.[33,34,35]

1d. Systemic antiepileptics (GABA (gamma-amino butyric acid) analogues): The gamma-amino-butyric acid (GABA) analogues like the pregabalin and gabapentin were conventionally employed as therapeutic adjunct towards the management of partial seizures.[36] These both pregabalin and gabapentin are effective in reducing the perioperative pain intensity, opioid consumption and opioid-related side effects, producing very few adverse effects.[37,38,39,40]

Preoperative analgesic regimens:

1.Parenteral and oral non steroidal drugs (NSAIDS):

Non-steroidal anti-inflammatory drugs (NSAIDs) involve a category of drugs that have an analgesic and antipyretic actions. Many studies found that the preemptive use reduces postoperative opioid requirement and delay time of first opioid dose needed for pain control. (36)

Preemptive analgesia has become a popular adjunct to conventional postoperative pain control. The concept of preemptive analgesia is based on the hypothesis that the most effective way to eliminate or reduce postoperative pain is to prevent nociceptive input from afferent stimuli to the central nervous system (CNS) so that CNS hyperexcitability does not occur. Clinically this strategy predicts not only less pain during the initial postoperative period but also a reduced intensity of pain during the days after the procedure. (37)

Although the nonselective cyclooxygenase (COX) inhibitors exhibit opioid-sparing properties and improved postoperative analgesia they are associated with increased risk of bleeding. Even a single dose of ketorolac inhibits platelet aggregation which may increase the risk of bleeding after surgery. (38)

Therefore, recent research indicates that cyclooxygenase-2 (COX-2) inhibitors (selective class of NSAIDs) could play an important role in perioperative pain management by reducing the inflammatory response in the periphery, modulating nociceptors, and attenuating central sensitization. The COX-2 inhibitors provide effective pain control in addition to a lesser degree of platelet dysfunction, renal impairment prolonged and gastrointestinal toxicity compared nonselective NSAIDs. (39)

2. Opioids:

Opioids have long been for the treatment knee arthritis and perioperative pain patients undergoing TKA and revision knee arthroplasty. inhibits the conduction pain signals through of opioid through several delivery methods, as oral, intravenous, intramuscular, subcutaneous and transdermal. In USA approximately one third of TKA patients used opioids within months prior to surgery (40).

Although opioids are effective pain management TKA, there are some adverse effects associated them; such as itchiness, nausea, somnolence, respiratory depression, retention urine, constipation. risk falling, long-term opioid medications may tolerance and dependence require achieve same Also opioid associated with early revision, postoperative complications, worse clinical outcomes developed tolerance hyperalgesia, which can complicate recovery and rehabilitation. (40-41)

3. Gabapentnoids (gamma-aminobutyric acid analogues):

Gabapentin and pregabalin are antiepileptic drugs but can also be used in the treatment of neuropathic pain, they interact with calcium channel $\alpha 2 - \delta$ ligands to inhibit calcium influx and subsequent release of excitatory neurotransmitters. They were conventionally employed as therapeutic adjunct towards the management of partial seizures. (42)

They are effective in reducing the perioperative pain intensity, opioid consumption and opioid-related side effects, producing very few adverse effects such as dizziness, light headedness and visual disturbances. (43-44)

Intraoperative analgesic regimens:

1. Local infiltration analgesia (LIA):

Local infiltration analgesia (LIA) has received an increasing interest in recent years because of the associated low risk, simple performance, low complication rates, and reduced local anesthetic systemic toxicity. It is performed by a surgeon intraoperatively without specialist equipment. Local anesthetic combined with opioids, antibiotics, NSAID or epinephrine (cocktail) are injected into periarticular regions, including the posterior capsule, collateral ligaments, capsular incision, the quadriceps tendon, and subcutaneous tissues, which directly prevents the generation and conduction of pain signals from incision. (45)

It has become an alternative analgesic regimen to femoral nerve block (FNB) without resulting in impairment of quadriceps muscle strength. Nevertheless, there is still no consensus on the optimal composition and infiltration technique of LIA. A meta-analysis conducted by Zhang LK et al. showed that LIA was as effective as FNB in terms of visual analog scale score for pain control, total morphine consumption, range of motion, complications, and length of hospital stay. (46)

Another meta-analysis conducted by Hu et al. showed that LIA provided superior postoperative pain relief at rest and preserved quadriceps function in the early postoperative period compared with epidural analgesia and peripheral nerve block. These results suggest that LIA is a viable and safe alternative to FNB for postoperative pain management after TKA without impairment of quadriceps muscle function. (47)

2. Spinal anesthesia :

The pain management after TKA is affected by the type of anesthesia used for the surgery. Both general and spinal anesthesia are appropriate for TKA but spinal anesthesia is becoming more popular, General anesthesia is associated with reduced perioperative tissue oxygen tension, postoperative nausea, vomiting, and delirium. Compared with general anesthesia, spinal anesthesia is reported to be associated with a lower rate of superficial wound infection, blood transfusion, length of surgery, DVT and length of hospital stay. So, spinal anesthesia is initially considered the gold standard for knee arthroplasty. (48-50)

Although, SA is preferred than general anesthesia, it has some adverse effects such as backache, hypotension, total spinal anesthesia (most feared complication), neurological injury, spinal hematoma and rare complications such as arachnoiditis and transient neurological syndrome. (51)

Postoperative Analgesic Regimens:

A. Epidural analgesia

Epidural analgesia has been documented to be extremely beneficial for postoperative pain relief after knee replacement surgeries. This technique is one of most successful techniques for postoperative analgesia in TKA, therefore, epidural analgesia is widely used in routine clinical practice involving knee replacement surgeries. (52)

Compared with parenteral opioids, It provides better postoperative analgesia with less nausea, vomiting, and pruritus (53). It may be associated with many adverse effects, such as urinary retention and hypotension, But the main drawback of epidural anesthesia is inadvertent motor nerve block, which delays physical therapy and rehabilitation. (54-56)

B. Peripheral nerve blocks (PNB):

Peripheral nerve block is usually used to relieve post-operative pain after TKA and could significantly reduce opioids consumption and opioids related adverse effects, promote early mobilization and reduce length of hospital stay. (57)

There are many peripheral nerve blocks used to reduce pain postoperatively in TKA as the following:

1) Femoral nerve block (FNB):

Femoral nerve block (FNB) is a well documented option for postoperative analgesia following major knee surgery. Femoral nerve is the central nerve supply to the maximum portion of the knee joint with use of US as shown in figure (7). So, it can be recommended as it causes better analgesia and less adverse effects and it is one of the oldest blocks employed for TKA analgesia. (58)

It has been used because it provides excellent analgesia and relatively easy to perform. However, the biggest disadvantage of FNB is the risk of fall postoperatively and it's associated quadriceps weakness.(59)

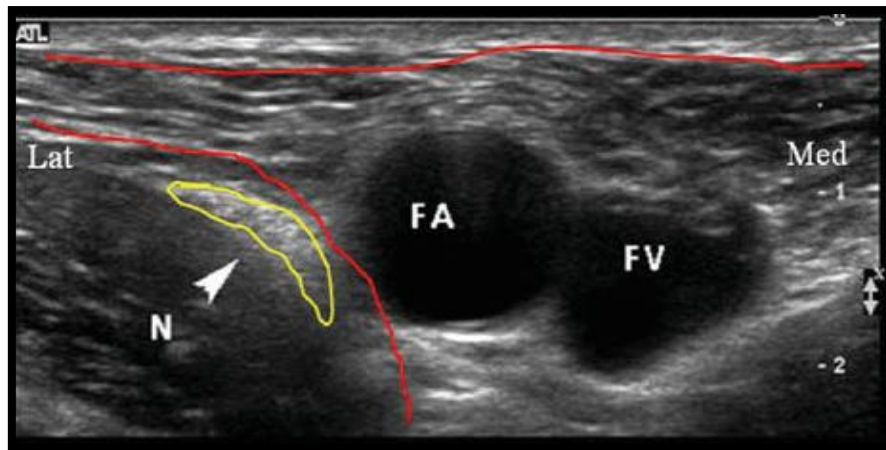


Figure 7: Ultrasound image showing femoral nerve, femoral artery and femoral vein Med; medial, Lat; lateral, top red line fascia latta, curved (lower) red line fascia iliaca (59). FA: femoral artery, FV: femoral vein, N: nerve.

2) Adductor canal block (sub sartorial block):

Adductor canal block (ACB) is one of the most important and most simple sensory nerve block for postoperative analgesia following knee surgery. It provides quality pain relief when compared to femoral nerve block and facilitates discharge of patients after total knee arthroplasty (61). It causes a good analgesic profile by maintaining quadriceps muscle strength, thereby causing earlier mobility and complete recovery (62-64). (Figure 8; showing an ultrasound image of ACB)

ACB could block the saphenous nerve, which is the largest sensory branch of the femoral nerve to the knee within the AC, while spares the major motor branches of the femoral nerve. Therefore, It can provide postoperative pain relief as effectively as FNB without impairment of quadriceps muscle strength, But like any PNB, it has some complications such as infection, nerve injury, vascular injury and hematoma. (65)

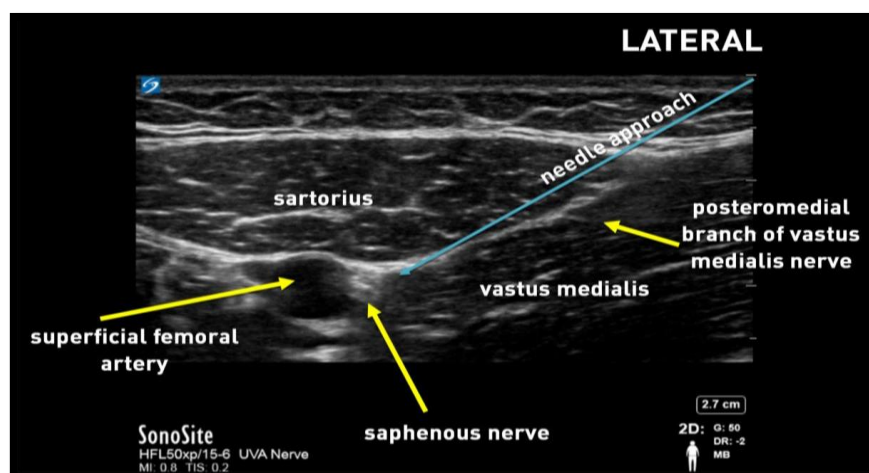


Figure 8: Ultrasound view of the adductor canal (ACB) demonstrating the saphenous nerve (62)

3) Sciatic nerve block (SNB):

SNB provides analgesia to the posterior knee pain by blocking the nerve at a proximal position in the peri-gluteal region. The performance of block within the immediate postoperative period can be quite challenging for the patient due to difficulty in patient positioning. (66-67)

It is commonly combined with FNB but it shows more problems due to it's muscle strength weakness while performing active exercises and more insecure walking, foot drop which may interfere early hospital ambulation and recovery. (68-69)

4) Obturator nerve (ONB):

When an obturator nerve block is performed in addition to a femoral nerve block, it can significantly reduce opioid consumption and pain after total knee arthroplasty compared with a single femoral nerve block or local anaesthetic infiltration. (70-71).

5) Infiltration between popliteal and capsule of posterior knee block (IPACK):

It is an ultrasound-guided approach targets serve analgesia of the posterior knee capsule. It is a motor-sparing block that provides analgesia of the posterior aspect of the knee without losing foot strength by blocking articular branches the obturator nerve, the common peroneal nerve and the tibial nerve in the popliteal region (71-72) Figure (9)

Types:

There are two approaches for IPACK block as the following:

* IPACK I (Lateral approach):

This can be performed using ultrasound by injecting the local anesthesia between the popliteal artery and the femoral shaft (73-74) (Figure (9; A).

* IPACK II (Posterior approach):

At the level of popliteal crease identification using ultrasound, the local anesthesia is injected in the intercondylar fossa between popliteal artery and femoral condyles (75-76)

(Figure (9; B).



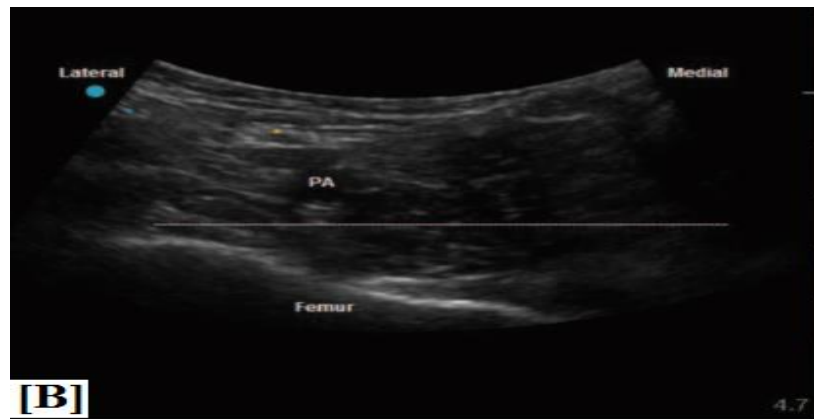


Figure 9: US image showing the two approaches of IPACK block.

A- lateral IPACK block, cross sectional view showing popliteal artery (PA), shaft of the femer and the needle position.

B- Posterior IPACK block, cross sectional view showing popliteal artery, femoral condyles and tibial nerve (white arrow) (74).

C. Patient controlled analgesia (PCA):

Patient controlled analgesia (PCA) is widely used for pain management in patients after TKA to provide simple, fast, and adequate pain relief without a specialized anesthesiologist postoperatively. It is the gold standard option for post-operative pain relief. The device is programmed according to the analgesic used, the physical characteristics, and the baseline pain of the patients. A small amount of analgesic could be delivered by the patients pressing the button when they most need it. Usually, opioids are used in PCA, such as oxycodone, morphine and fentanyl. (77-80)

PCA is safe and effective for treating moderate to severe pain and has become increasingly popular for use in patients undergoing TKA. (81-83)

Currently, opioid drugs are commonly administered by PCA, adding to multimodal analgesia but it may increase risk of falling as a side effect of opioide use.(40)

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