Chapter 6

Pain Management

Yavuz Orak and Mahmut Arslan

Additional information is available at the end of the chapter

http://dx.doi.org/10.5772/intechopen.74296

Abstract

Postoperative pain is caused by neuronal damage that occurs during the surgical procedure and the stimulation of the nociceptors. In postoperative period, total knee arthroplasty (TKA) is painful, and pain management is quite difficult. The main purpose of postoperative pain relief is to reduce the pain of the patient, to contribute to the healing process, to shorten the length of hospital stay, and to reduce hospital costs. Techniques such as intravenous analgesia, epidural analgesia, and peripheral nerve blocks are used to prevent postoperative pain. In addition, oral and parenteral analgesics, patient-controlled analgesia (PCA), nerve blocks, and periarticular injection methods are used as multimodal analgesia methods. Pain scales such as visual analogue scale (VAS), verbal descriptive scale (VDS), and numerical rating scale (NRS) are used as the standard methods in the evaluation of pain of patients. Systemic opioids, nonsteroidal anti-inflammatory drugs, and local anesthetics are used for postoperative analgesia. Preemptive analgesia, defined as analgesia initiated prior to surgical incision, and multimodal analgesia have been shown to reduce opioid consumption associated with high complication rates. Postoperative pain management should be planned considering the clinical characteristics of the patient, experience of the anesthetist, and clinical facilities. Early postoperative analgesia reduces systemic complication rates and improves early rehabilitation, patient satisfaction, and quality of life.

Keywords: pain management, analgesia, preemptive analgesia, multimodal analgesia, regional analgesia techniques, drug therapy

1. Introduction

According to the definition made by the International Organization for Research on Aging (IASP), pain is a sensorial, emotional, unpleasant sensation about someone's past experiences, whether they are connected to an organic gown or not, starting from anywhere in the body.

2. Classification of pain

1. Acute pain: it is a type of pain that starts suddenly, has a nociceptive nature, has tissue damage, shows a close relationship with the cause of the lesion in terms of location, time, and intensity, and gradually disappears as the healing progresses [1, 2]. The most common types of acute pain are posttraumatic, postoperative, and obstetric pain [3].
2. Superficial (cutaneous) pain: it is type of a pain that occurs against nociceptive stimuli that occur in skin, subcutaneous tissue, and mucous membranes.
3. Deep somatic pain: it is a pain that is usually caused by muscle, tendon, joint receptors or bones, which is blunt and cannot be localized.
4. Visceral pain: it is a pain originated from the deterioration of functions of their tissue (parietal pleura, pericardium, and peritoneum).
5. Chronic pain: it is defined as acute pain that begins as acute pain and lasts for 1–6 months [4].

3. Pain pathways

In order for a stimulus to be perceived as pain, it is necessary to go through four different physiological processes:

a. Transduction; at the end of the nerve is the stage where the stimulus is converted into electrical activity.

b. Transmission; it is the spread of electrical activity throughout the nervous system.

c. Modulation; changes in nociceptive transmission.

d. Perception; interaction with the individual's psychology and subjective emotional experiences.

4. Postoperative pain in total knee arthroplasty

Postoperative pain is caused by neuronal damage that occurs during the surgical procedure and the stimulation of the nociceptors. In postoperative period, total knee arthroplasty (TKA) is painful and pain management is quite difficult. The main purpose of postoperative pain relief is to reduce the pain of the patient, to contribute to the healing process, to shorten the length of hospital stay, and to reduce hospital costs.

Techniques such as intravenous analgesia, epidural analgesia, and peripheral nerve blocks are used to prevent postoperative pain. In addition, oral and parenteral analgesics, patient-controlled analgesia, nerve blocks, and periarticular injection methods are used as multimodal analgesia method. Systemic opioids, nonsteroidal anti-inflammatory drugs, and local anesthetics are frequently used for postoperative analgesia.

http://dx.doi.org/10.5772/intechopen.74296

Pain scales such as visual analogue scale (VAS), verbal descriptive scale (VDS), numerical rating scale (NRS) are used as standard methods in the evaluation of pain of patients.

Total knee arthroplasty (TKA) is known to be a very painful orthopedic procedure [5]. For this reason, effective pain control is important to optimize the rehabilitation process in order to ensure patient satisfaction, hospital stay, and cost reduction [6]. However, the difficulty of postoperative pain management after TKA is to maintain adequate motor function with adequate analgesia. The patient is informed about the surgery to be performed before the operation, and a training program and the physical preparation are recommended. Patients undergoing preoperative exercise and training showed significant improvements in function, quadriceps strength, and duration of stay. After the surgical intervention is performed, the patient can continue the rehabilitation program to speed up the healing process in the home under the supervision of a physiotherapist. Rehabilitation therapy depends on many factors such as patient characteristics, prosthesis characteristics, and postoperative complications.

More than 1.1 million joint arthroplasty (TJA) are performed annually in the USA, and more than 700,000 of them are primary TKA [7, 8].

5. Pathophysiological changes caused by postoperative pain in the organism

Acute postoperative pain that is poorly treated is associated with both physiological and psychological functions in the body [2, 9–11], which are as follows:

- Cardiovascular system: coronary ischemia, myocardial infarction
- Pulmonary system: hypoventilation, decreased vital capacity, pulmonary infection
- Gastrointestinal system: reduced motility, ileus, nausea, vomiting
- Renal system: increases in urinary retention and sphincter tone, oliguria

There are negative effects on the muscular system, on the coagulation system, on the wound healing, and on the immune system. Finally, poorly controlled pain after surgery may impair sleep and have negative psychological effects, such as demoralization and anxiety.

6. Postoperative pain treatment/management methods

1. Regional analgesia techniques and multimodal analgesia
2. Drug therapy
3. Nonpharmacological techniques
4. Preemptive analgesia
5. Patient education

6.1. Regional analgesia techniques and multimodal analgesia

Despite improvements in pain management, approximately half of TKA (total knee arthroplasty) patients develop severe pain in the early postoperative period. Excessive tissue damage and complex innervation in TKA make pain control difficult. Femoral nerve, sciatic nerve, and obturator nerve are involved in the innervation of the knee joint. In major surgeries, such as TKA, changes occur in the endocrine system and central, peripheral, and sympathetic nervous systems. If postoperative analgesia is not achieved adequately, systemic responses induced by the surgery increase and serious risks may occur to the patients.

Conventional methods such as parenteral opioids, epidural analgesia, and femur blocks have been widely used to remove the pain associated with TKA [12]. In addition, the fascia iliaca block has recently been used more frequently to reduce the pain associated with TKA [13]. Comparing general anesthesia with neuraxial anesthesia in the patients with TKA, the risk of perioperative complications was significantly reduced in patients undergoing neuraxial anesthesia [14]. In another study, the risk of short-term complications in patients with TKA was higher in patients receiving general anesthesia than in patients receiving neuraxial anesthesia [15]. Neuraxial anesthesia was associated with the reduction of major complications. A recent meta-analysis has shown that there is a significant decrease in the incidence of postoperative surgical site infection in neuraxial anesthesia when compared to general anesthesia and neuraxial anesthesia in the patients with TKA and total hip arthroplasty (THA) [16]. The use of peripheral nerve block (PNB) also reduced the need for postsurgical critical care services [17].

Multimodal analgesia techniques are often used in the "fast-track" recovery protocols to improve pain relief. Mixture of local anesthetics and anti-inflammatory and opioid analgesics for periarticular infiltration has been used in the multimodal protocols. It can improve the pain score, reduce the total perioperative opioid consumption, enhance the early mobilization, and increase the patient satisfaction [18]. Several multimodal analgesics have been developed in clinical practice [19, 20] and paracetamol, nonsteroidal anti-inflammatory drugs (NSAIDs), opioids, ketamine [21], alpha-2 adrenergic agonists [22], and corticosteroids have been used [23].

Periarticular drug injection is an attempt to apply a low-concentration, high-volume local anesthetic solution to the joint capsule and periarticular surrounding tissues to provide postoperative analgesia [24]. When used as a part of a multimodal analgesic protocol in patients undergoing TKA, femoral nerve blockade has been shown to reduce narcotic consumption and improve postoperative pain scores [25]. However, periarticular infiltration is usually insufficient to provide adequate analgesia in the anterior direction of the knee [26]. Periarticular infiltration analgesic protocols that infiltrate anterior, posterior, and medial compartments of the knee are reported to only last between 6 and 12 h [27]. Prolonged motor blockade, quadriceps muscle weakness, difficulty ambulating, and postoperative falls limit the utility of femoral nerve block (FNB) in the "fast track" rehabilitation protocols [28, 29]. In a study, Fascia iliaca block effectively reduced the amount of morphine used after TKA in the first 24 h. This study shows that the fascia iliaca block provides the same level of analgesia with the use of less morphine compared with the periarticular injection [30]. However, the fascia iliaca block requires as much as 40–50 mL of volume to achieve an effective result [31]. In another study, the analgesic efficacy of the fascia iliaca block was compared to the femur nerve block in the guideline

of ultrasonography and no difference was found in VAS scores and opioid consumption [32]. The sciatic nerve block (SNB) is used in addition to FNB for complete analgesia after TKA. In a systematic review, SNB administered as a supplement to FNB has shown that it does not provide adequate analgesic activity [33]. Studies with larger patient groups showed a significant reduction in postoperative opioid consumption, less opioid-induced adverse effects, and significantly lower resting and dynamic pain scores [34–38]. Adductor channel block was also studied. In the meta-analysis study performed, there was no significant difference in pain control and morphine consumption between the adductor canal bloc (ACB) and the femoral nerve block (FNB) group. However, it was observed that ACB provided faster postoperative mobilization ability without reduction of analgesia in patients undergoing TKA [39]. Another study conducted after TKA to compare the efficacy of single-shot adductor canal block (SACB) and postoperative continuous adductor canal block (CACB) placement and showed that CACB was superior to SACB for analgesia control but ambulation ability, success rate, early functional recovery, and treatment-related side effects were similar [40]. Different studies have shown that ACB and FNB have similar motor function recovery, strength ratings, and quadriceps muscle strength at postoperative 24 and 48 h in TKA patients [41, 42].

6.2. Drug therapy

TKA operation is one of the most painful orthopedic procedures [43]. For this reason, it is difficult to provide adequate analgesia with a single drug or method. Multimodal analgesia methods will be more appropriate to reduce side effects and provide pain control. Multimodal analgesia is defined as providing more effective pain control by the combined use of various analgesic drugs and techniques that may have additive or synergistic effects targeting different pain mechanisms in the peripheral and/or central nervous system [44].

In multimodal pain management, patient education, preemptive oral medications, regional anesthesia methods, peripheral nerve blocks, local infiltrations, and postoperative rehabilitation are included. Most of the side effects seen in analgesia treatment are due to the parenteral opioid. One of the main goals of multimodal analgesia is to reduce the need for opioids.

6.2.1. Nonsteroidal anti-inflammatory drugs

Tissue inflammation in TKA surgery triggers the production of PGs that play a role in acute postoperative pain. NSAIDs reduce central sensitization by inhibiting central and peripheral prostaglandin synthesis. It may be effective for 2 weeks when inflammation continues in the postoperative period. Ketorolac is a nonselective COX inhibitor and has oral, parenteral, ophthalmic, and nasal forms. It is used in moderate and severe postoperative pain management after major surgeries [45]. It reduces opioid consumption when used as a part of multimodal pain management [46]. The use of NSAIDs can cause gastritis or peptic ulcer formation and impair platelet aggregation, renal function, and wound healing. For this reason, there are concerns about their use in the perioperative period. Preemptive use of selective COX-2 (cyclooxygenase) inhibitors (celecoxib and rofecoxib) has been shown to reduce postoperative pain scores in the knee surgeries [47]. The use of selective COX2 inhibitors in TKA surgeries has been shown to reduce opioid consumption, provide early onset of physical rehabilitation, and reduce

nausea and vomiting [48]. Similarly, diclofenac or ketorolac administered in a single dose in joint arthroplasty patients reduced morphine consumption by 29% compared to placebo [49].

6.2.2. Paracetamol

It is nonopioidand and non-NSAID analgesic. It inhibits prostaglandin synthesis in the CNS and plays a role in preventing central sensitization. There is a minimal effect on peripheral PG synthesis. Unlike NSAIDs, the anti-inflammatory effect is poor, and there are no negative effects on platelet function and gastric mucosa. It has been shown that 1 g intravenous paracetamol provides rapid and effective analgesia in major orthopedic surgeons [50]. Paracetamol can be administered 1 g/day four times. When combined with paracetamol and NSAIDs, better analgesia is achieved when both drugs are used alone [51].

6.2.3. Glucocorticoids

Glucocorticoids have strong anti-inflammatory effects. Corticosteroids are thought to be an important component because of their local anti-inflammatory effects and their ability to reduce the local stress response in the operation [52]. There have been many studies on corticosteroids, and conflicting evidence has been obtained about their benefits [53–58]. Some studies have shown that postoperative pain is improved with corticosteroids [53–56] but other studies do not benefit [57, 58]. In another study, postoperative pain level was lower in the corticosteroid group than that in the noncorticosteroid group in first 24 h [59]. In a meta-analysis, dexamethasone, a long-acting glucocorticoid, has been shown to reduce postoperative pain and opioid consumption [60]. In one study, it was shown that preoperative single dose iv 40 mg dexamethasone reduced dynamic pain scores [61]. Another study showed that dexamethasone administered as a part of multimodal analgesia in 269 patients undergoing TKA reduced postoperative pain and bulimia and did not increase wound complications [62]. In contrast to these studies, patients with a periarticular injection with high- and low-dose corticosteroids were compared and found no improvement in postoperative pain level [58]. Surgical techniques such as the surgical approach and the use of pneumatic turniken may be effective on early postoperative pain [63, 64]. One of the most commonly used corticosteroids for periarticular injection is methylprednisolone [52, 57, 65–67].

6.2.4. Opioids

Opioids have been used to provide analgesia and relieve anxiety for centuries. Opioid receptors are found in many regions of the CNS. These receptors are located in the central nervous system, cerebral cortex, hypothalamus, thalamus, midbrain extrapyramidal area, substantia gelatinosa, and sympathetic preganglionic nerves. Places with the highest concentration of these receptors are structures and pathways associated with pain [68].

The first opioid receptors were found in 1973. Later, endogenous opioids were found. There are four types of receptors. These include mu (μ), kappa (k), sigma (s), and delta (d) receptors. Opioids show their effect by linking their receptors.

http://dx.doi.org/10.5772/intechopen.74296

1. Mu (μ) receptors: specific morphine agonist. It is stimulated by morphine and is responsible for supraspinal analgesia.
2. Kappa (k) receptors: they are responsible for spinal analgesia and sedation.
3. Sigma (s) receptors: responsible for dysphoria and hallucinations.
4. Delta (d) receptors: beta-endorphin and encephalin are specific agonists. It is influential on motor integration and urine function.

Classification of opioids:

1. Natural opioids: phenanthrene derivatives: codeine, morphine, and thebaine. Benzylisoquinoline derivatives: papaverine.
2. Synthetic opioids: phenylpiperidine derivatives (fentanyl, sufentanil, and meperidine), benzomorphan derivatives (pentazocine and phenazocine), diphenylpropyl or methadone derivatives (methadone and d-propoxyphene), and morphinan derivatives (levorphanol).
3. Semisynthetic opioids: dihydromorphone/morphinone, heroin, and thebaine derivatives (etorphine).

Morphine contains the basic properties of the majority of the structures of the opioids. The effects of morphine in the central nervous system, analgesia, euphoria and sedation. The most important effect of morphine on the central nervous system therapeutically is analgesia.

Analgesia provided by systemic opioids often accompanies side effects such as sedation, nausea, pruritus, urinary retention, and constipation. However, they continue to be an important part of severe postoperative pain management [69]. They can be used intramuscularly, intravenously, orally, rectally, sublingually, subcutaneously, epidurally, or intrathecally. If patients are able to use the oral route, oral administration is recommended. Side effects of oral opioids are less frequent and are mostly related to the gastrointestinal system. Intravenous patient-controlled analgesia (PCA) should be preferred if the parenteral route is used. Intravenous opioid PCA is recommended for bolus application with appropriate lock interval without basal infusion. In the postoperative period, it is usually administered via intravenous PCA for the first 24–48 h and then is used as oral agents [44]. Oral opioids have immediate release and controlled release forms [70]. Rapid-release patients are effective in the treatment of moderate and severe postoperative pain, but are impractical because they need to be reapplied every 4 h. Since postoperative pain is continuous at the beginning, analgesics should be used regularly especially in the first 24 h. Long-acting oxymorphone and oxycodone have been shown to be effective in postoperative analgesia in TKAs [71, 72]. Especially morphine and fentanyl are frequently used for postoperative analgesia in TKA cases. The application of intrathecal morphine and fentanyl is very effective in postoperative pain control. In a study conducted, 0.2 mg and 0.3 mg intrathecal morphine administration was shown to be effective for postoperative analgesia [73]. Other studies have been done to support this study. The use of 0.5 mg intrathecal morphine has been shown to be more reliable and more effective than injections of 0.2 mg [74].

Intrathecal morphine is less hydrophobic than other opioids, has a longer duration in the cerebrospinal fluid, and provides very good postoperative analgesia [75]. On the other hand, another study reported that morphine should not be used even in small doses due to these side effects [76]. Opioids are known to produce more effective and long-lasting anesthesia when used with local anesthetics. Opioids are known to produce more effective and long-lasting anesthesia when used with local anesthetics [77, 78]. In a study of TKA cases, we compared the use of intrathecal morphine and fentanyl for postoperative analgesia and found that fentanyl provided more effective postoperative analgesia [79]. Long-acting opioids (LAO) are often used for malignant, nonmalignant, and different pain treatments. A lot of work about LAO (oxycodone, morphine) has been done in this regard. In a study on LAO, there was a decrease in pain while there was an increase in vomiting and sedation [80]. After the use of LAO (oxycodone), the rehabilitation of patients was found to be better in TKA cases [81]. In the studies performed, intravenous PCA and oxycodone were compared and there was no difference in pain [82], and no difference in pain after LAO (oxycodone) used after total joint arthroplasty [83].

6.2.5. Gabapentinoids (gabapentin and pregabalin)

Gabapentin has been shown to be effective in the treatment of herpetic neuralgia, neuropathic pain [84], and diabetic neuropathy [85]. These anticonvulsant drugs, which have been used for a long time in the management of chronic pain, have started to be used in acute postoperative analgesia in recent years. They may cause side effects such as sedation and dizziness. It has been shown that administration of pregabalin (300 mg preoperatively and 150–50 mg twice daily for the first 14 days postoperatively) reduces the incidence of opioid consumption and neuropathic pain development after TKA [86]. We also have studies showing that postoperative analgesia is reduced after the application of preoperative gabapentin and pregabalin in lower extremity surgeons [87, 88]. Another study has shown that gabapentin effectively reduces postoperative narcotics consumption and pruritus incidence [89]. In another meta-analysis trial, the use of pregabalin shows that it could improve pain control at 24 and 48 h with rest, reduce morphine consumption, and improve knee flexion level, as well as reduce nausea, vomiting, and pruritic event rate. However, pregabalin increased the incident rate of dizziness after total knee arthroplasty (TKA) and total hip arthroplasty (THA) but could not improve the pain control at 72 h with rest [90].

6.2.6. Ketamine

Ketamine is used by anesthetists for sedation and general anesthesia. With the detection of the N-methyl-ᴅ-aspartate receptor's role in nociceptive pain transmission and central sensitization, ketamine has begun to be used as a potential antihyperalgesic agent. Subanesthetic low doses of ketamine provide significant analgesic efficacy without psychomimetic side effects [45]. Low-dose ketamine has no adverse effects on respiratory and cardiovascular system and does not cause nausea-vomiting, urinary retention and constipation or postoperative ileus. In patients receiving TKA, low-dose ketamine infusion has been shown to reduce morphine consumption postoperatively (3 μg/kg per minute intraoperatively and 1.5 μg/kg per minute for 48 h) [91].

http://dx.doi.org/10.5772/intechopen.74296

6.3. Nonpharmacological techniques

There have been many studies on surgical techniques and equipment, but most have had no or limited effect on postoperative analgesia. These studies focused on drains, surgical approaches, tourniquet use, prosthetic types, and reshaping of the patellar surface. A comparison of cooling and compression techniques with the control group showed that postoperative pain and morphine consumption were reduced [92]. The efficacy of TENS administration in postoperative analgesia after TDP was not demonstrated [93]. The results of cryotherapy are contradictory. The potential benefits of cryotherapy in a meta-analysis are not clinically significant [94]. Routine use is therefore not recommended.

6.4. Preemptive analgesia

Analgesics are administered before painful stimulation to prevent peripheral and central sensitization. Preemptive analgesia inhibits peripheral sensitization and central sensitization. It should also prevent inflammatory and neuropathic pain types [95]. Local anesthetic infiltration, regional anesthesia methods, and drugs (NMDA receptor antagonists, opioids, COX-2 inhibitors, nonsteroidal anti-inflammatory drugs (NSAID), and local anesthetics) can be used for preemptive analgesia. According to a study, preemptive analgesia is statistically significant, although not clinically significant [96]. When preemptive analgesia is administered, it should be considered as a method of pathological pain as well as physiological conventional perioperative analgesia [97]. Preemptive analgesia is an effective method in clinical practice for the approach to postoperative pain involving incisional and inflammatory injury [98].

Drugs used in preemptive analgesia:

1. Local anesthetics
2. Nonsteroidal anti-inflammatory drugs (NSAIDs)
3. COX-2 inhibitors
4. Opioids
5. NMDA receptor antagonists

6.5. Patient education

There are two major components of pain perception: the sensory discriminative component and the motivational affective component [99]. Emotional component is targeted with patient education. Patients and their relatives are informed, and their anxiety is reduced by eliminating their fears about the unknown; the realistic goals are identified, and a relationship is established with patients and their relatives; the patient satisfaction increases, and the pain scores decrease [100].

7. Conclusion

In TKA, many methods are proposed and used for postoperative pain management. There are many factors that affect postoperative pain management. The age of the patient, the experience of the surgeon, the technical conditions, and the method used are some of these. Taking all these factors and literature into consideration, the use of multimodal analgesia techniques is recommended.

Systemic medications for postoperative analgesia after TKA:

1. Paracetamol
2. NSAIDs
    a. Celecoxib
    b. Ibuprofen
    c. Naproxen
    d. Ketorolac
3. Ketamine
4. Gabapentinoids
    a. Gabapentin
    b. Pregabalin
5. Glucocorticoids
6. Opioids
    a. Morphine
    b. Fentanyl
    c. Hydromorphone
    d. Hydrocodone
    e. Tramadol
    f. Extended-release oxycodone
    g. Extended-release morphine

8. Key rules in knee rehabilitation

1. Bone-bond stability is a prerequisite for optimal knee function recovery [101, 102].
2. Postsurgery rehabilitation program should be started early.

3. During the rehabilitation program, unbalanced and full weight should not be allowed until a normal range of motion and walking pattern is achieved.
4. The development of reflex inhibition in the extensor or flexor mechanisms should be recognized early and must be struggled in the appropriate modalities.
5. The operated and unoperated extremities should be strengthened together.
6. For the success of the rehabilitation program, orthopedic surgeon, physical medicine and rehabilitation specialist, physiotherapist, occupational therapist, nurse, and the social team of service specialists need to communicate well.

Author details

Yavuz Orak* and Mahmut Arslan

*Address all correspondence to: dryavuzorak@hotmail.com

Anesthesiology and Reanimation Department, Faculty of Medicine, Kahramanmaras Sutcu Imam University, Kahramanmaraş, Turkey

References

[1] Ferrante FM, Vadebonconer TR. Postoperative Pain Management. 2nd ed. New York: Churchill Livingstone Inc.; 1993. pp. 485-518

[2] Carr DB, Goudas IC. Acute pain. Lancet. 1999;**353**:2051

[3] Basbaum AI, Jessel T. The perception of pain. In: Kandel ER, Schwartz J, Jessel T, editors. Principles of Neuroscience. New York: Appleton and Lange; 2000. p. 472

[4] Craig AD, Bushnell MC, Zhang ET, Blomqvist A. A thalamic nucleus specific for pain and temperature sensation. Nature. 1994;**372**:770-773

[5] Gerbershagen HJ, Aduckathil S, van Wijck AJM, Peelen LM, Kalkman CJ, Meissner W. Painintensityon the first day after surgery:A prospective cohort study comparing 179 surgical procedures. Anesthesiology. 2013;**118**(4):934-944

[6] Liu SS, Wu CL. The effect of analgesic technique on postoperative patient-reported outcomes including analgesia: A systematic review. Anesthesia and Analgesia. 2007; **105**(3):789-808

[7] Hall MJ, DeFrances CJ, Williams SN, Golosinskiy A, Schwartzman A. National hospital discharge survey: 2007 summary. National Health Statistics Reports. 2010:1-20, 24

[8] Ethgen O, Bruyere O, Richy F, Dardennes C, Reginster JY. Health-related quality of life in total hip and total knee arthroplasty. A qualitative and systematic review of the literature. The Journal of Bone and Joint Surgery. American Volume. 2004;**86**:963-974

[9] Breivik H. Postoperative pain management: Why is it difficult to show that it improves outcome? European Journal of Anaesthesiology. 1998;**15**(6):748-751

[10] Joshi GP, Ogunnaike BO. Consequences of inadequate postoperative pain relief and chronic persistent postoperative pain. Anesthesiology Clinics of North America. 2005; **23**(1):21-36

[11] Kehlet H. Multimodal approach to control postoperative pathophysiology and rehabilitation. British Journal of Anaesthesia. 1997;**78**(5):606-617

[12] Galimba J. Promoting the use of periarticular multimodal drug injection for total knee arthroplasty. Orthopaedic Nursing. 2009;**28**:250-254 [quiz 255]

[13] Brisbane Orthopaedic & Sports Medicine Centre Writing Committee, McMeniman TJ, McMeniman PJ, Myers PT, Hayes DA, Cavdarski A, et al. Femoral nerve block vs fascia iliaca block for total knee arthroplasty postoperative pain control: A prospective, randomized controlled trial. The Journal of Arthroplasty. 2010;**25**:1246-1249

[14] Memtsoudis SG, Sun X, Chiu YL, et al. Perioperative comparative effectiveness of anesthetic technique in orthopedic patients. Anesthesiology. 2013;**118**:1046-1058

[15] Pugely AJ, Martin CT, Gao Y, Mendoza-Lattes S, Callaghan JJ. Differences in short-term complications between spinal and general anesthesia for primary total knee arthroplasty. The Journal of Bone and Joint Surgery. American Volume. 2013;**95**:193-199

[16] Chang CC, Lin HC, Lin HW. Anesthetic management and surgical site infections in total hip or knee replacement: A population-based study. Anesthesiology. 2010;**113**:279-284

[17] Memtsoudis SG, Stundner O, Rasul R, et al. Sleep apnea and total joint arthroplasty under various types of anesthesia: A population-based study of perioperative outcomes. Regional Anesthesia and Pain Medicine. 2013;**38**:274-281

[18] Lamplot JD, Wagner ER, Manning DW. Multimodal pain management in total knee arthroplasty: A prospective randomized controlled trial. The Journal of Arthroplasty. 2013;**29**:329-334

[19] Chan E-Y, Fransen M, Sathappan S, Chua NHL, Chan Y-H, Chua N. Comparing the analgesia effects of singleinjection and continuous femoral nerve blocks with patient controlled analgesia after total knee arthroplasty. Journal of Arthroplasty. 2013;**28**(4):608-613

[20] Chang CB, Cho W-S. Pain management protocols, peri-operative pain and patient satisfaction after total knee replacement: A multicentre study. The Journal of Bone & Joint Surgery—British Volume. 2012;**94**(11):1511-1516

[21] Adam F, Chauvin M, Du Manoir B, Langlois M, Sessler DI, Fletcher D. Small-dose ketamine infusion improves postoperative analgesia and rehabilitation after total knee arthroplasty. Anesthesia and Analgesia. 2005;**100**(2):475-480

[22] Blaudszun G, Lysakowski C, Elia N, Tram'er MR. Effect of perioperative systemic α2 agonists on postoperative morphine consumption and pain intensity: Systematic review and meta-analysis of randomized controlled trials. Anesthesiology. 2012;**116**(6):1312-1322

[23] Lunn TH, Kristensen BB, Andersen LØ, et al. Effect of high-dose preoperative methylprednisolone on pain and recovery after total knee arthroplasty: A randomized, placebocontrolled trial. British Journal of Anaesthesia. 2011;**106**(2):230-238

[24] Ng FY, Ng JKF, Chiu KY, Yan CH, Chan CW. Multimodal periarticular injection vs continuous femoral nerve block after total knee arthroplasty: A prospective, crossover, randomized clinical trial. The Journal of Arthroplasty. 2012;**27**:1234-1238

[25] Paul JE, Arya A, Hurlburt L, et al. Femoral nerve block improves analgesia outcomes after total knee arthroplasty: A meta-analysis of randomized controlled trials. Anesthesiology. 2010;**113**:1144-1162

[26] Sanna M, Sanna C, Caputo F, Piu G, Salvi M. Surgical approaches in total knee arthroplasty. Joints. 2013;**1**:34-44

[27] Andersen L, Kehlet H. Analgesic efficacy of local infiltration analgesia in hip and knee arthroplasty: A systematic review. British Journal of Anaesthesia. 2014;**113**:360-374

[28] Sharma S, Iorio R, Specht LM, Davies-Lepie S, Healy WL. Complications of femoral nerve block for total knee arthroplasty. Clinical Orthopaedics and Related Research. 2010;**468**:135-140

[29] Kandasami M, Kinninmonth AW, Sarungi M, Baines J, Scott NB. Femoral nerve block for total knee replacement—Aword of caution. The Knee. 2009;**16**:98-100

[30] Bali C, Ozmete O, Eker HE, Hersekli MA, Aribogan A. Postoperative analgesic efficacy of fascia iliaca block versus periarticular injection for total knee arthroplasty. Journal of Clinical Anesthesia. 2016 Dec;**35**:404-410. DOI: 10.1016/j.jclinane.2016.08.030 Epub 2016 Oct 14

[31] Range C, Egeler C. Fascia Iliaca compartment block: Landmark and ultrasound approach. http://www.frca.co.uk/Documents/193%20Fascia%20Iliaca%20compartment%20block.pdf

[32] Kong M, Guo R, Chen J, Li P, Wu Z. Arandomized study to compare the analgesic efficacy of ultrasound-guided block of fascia Iliaca compartment or femoral nerve after patella fracture surgery. Cell Biochemistry and Biophysics. 2015;**72**:567-570

[33] Abdallah FW, Brull R. Is sciatic nerve block advantageous when combinedwithfemoralnerveblockfor postoperativeanalgesiafollowing total knee arthroplasty? A systematic review. Regional Anesthesia and Pain Medicine. 2011;**36**:493-498

[34] Wegener JT, van Ooij B, van Dijk CN, et al. Value of single-injection or continuous sciatic nerve block in addition to a continuous femoral nerve block in patients undergoing total knee arthroplasty: A prospective, randomized, controlled trial. Regional Anesthesia and Pain Medicine. 2011;**36**:481-488

[35] Pham Dang C, Gautheron E, Guilley J, et al. The value of adding sciatic block to continuous femoral block for analgesia after total knee replacement. Regional Anesthesia and Pain Medicine. 2005;**30**:128-133

[36] Morin AM, Kratz CD, Eberhart LH, et al. Postoperative analgesia and functional recovery after total-knee replacement: Comparison of a continuous posterior lumbar plexus (psoas compartment) block, a continuous femoral nerve block, and the combination of a continuous femoral and sciatic nerve block. Regional Anesthesia and Pain Medicine. 2005;**30**:434-445

[37] Hunt KJ, Bourne MH, Mariani EM. Single-injection femoral and sciatic nerve blocks for pain control after total knee arthroplasty. The Journal of Arthroplasty. 2009;**24**:533-538

[38] Abdallah FW, Chan VW, Gandhi R, et al. The analgesic effects of proximal, distal, or no sciatic nerve block on posterior knee pain after total knee arthroplasty: A double-blind placebo-controlled randomized trial. Anesthesiology. 2014;**121**:1302-1310

[39] Gao F, Ma J, Sun W, Guo W, Li Z, Wang W. Adductor canal block versus femoral nerve block for analgesia after total knee arthroplasty a systematic review and meta-analysis. Clinical Journal of Pain. April 2017;**33**(4)

[40] Shah NA, Jain NP, Panchal KA. Adductor canal blockade following total knee arthroplasty-continuous or single shot technique? Role in postoperative analgesia, ambulation ability and early functional recovery: A randomized controlled trial. The Journal of Arthroplasty. 2015;**30**:1476-1481

[41] Kim DH, Lin Y, Goytizolo EA, et al. Adductor canal block versus femoral nerve block for total knee arthroplasty: A prospective, randomized, controlled trial. Anesthesiology. 2014;**120**:540-550

[42] Memtsoudis SG, Yoo D, Stundner O, et al. Subsartorial adductor canal vs femoral nerve block for analgesia after total knee replacement. International Orthopaedics. 2015; **39**:673-680

[43] Buvanendran A, Fiala J, Patel KA, Golden AD, Moric M, Kroin JS. The incidence and severity of postoperative pain following inpatient surgery. Pain Medicine. 2015;**16**:2277-2283

[44] Chou R, Gordon DB, de Leon-Casasola OA, et al. Management of postoperative pain: A clinical practice guideline from the American Pain Society, the American Society of Regional Anesthesia and Pain Medicine, and the American Society of Anesthesiologists' Committee on Regional Anesthesia, Executive Committee, and Administrative Council. The Journal of Pain. 2016;**17**:131-157

[45] Kopp SL, Børglum J, Buvanendran A, Horlocker TT, Ilfeld BM, Memtsoudis SG, Neal JM, Rawal N, Wegener JT. Anesthesia and analgesia practice pathway options for total knee arthroplasty: An evidence-based review by the American and European Societies of regional anesthesia and pain medicine. Regional Anesthesia and Pain Medicine. 2017;**42**(6):683-697

[46] Dorr LD, Raya J, Long WT, Boutary M, Sirianni LE. Multimodal analgesia without parenteral narcotics for total knee arthroplasty. The Journal of Arthroplasty. 2008;**23**:502-508

[47] Reuben SS, Bhopatkar S, Maciolek H, Joshi W, Sklar J. The preemptive analgesic effect of rofecoxib after ambulatory arthroscopic knee surgery. Anesthesia and Analgesia. 2002; **94**:55-59

[48] Buvanendran A, Kroin JS, Tuman KJ, Lubenow TR, Elmofty D, et al. Effects of perioperative administration of a selective cyclooxygenase 2 inhibitor on pain management and recovery of function after knee replacement: A randomized controlled trial. JAMA. 2003;**290**:2411-2418

[49] Alexander R, El-Moalem HE, Gan TJ. Comparison of the morphine-sparing effects of diclofenac sodium and ketorolac tromethamine after major orthopedic surgery. Journal of Clinical Anesthesia. 2002;**14**:187-192

[50] Sinatra RS, Jahr JS, Reynolds LW, Viscusi ER, Groudine SB, Payen-Champenois C. Efficacy and safety of single and repeated administration of 1 gram intravenous acetaminophen injection (paracetamol) for pain management after major orthopaedic surgery. Anesthesia. 2005;**102**:822-831

[51] Ong CK, Seymour RA, Lirk P, Merry AF. Combining paracetamol (acetaminophen) with nonsteroidal antiinflammatory drugs: A qualitative systematic review of analgesic efficacy for acute postoperative pain. Anesthesia and Analgesia. 2010;**110**:1170-1179

[52] Parvataneni HK, Shah VP, Howard H, et al. Controlling pain after total hip and knee arthroplasty using a multimodal protocol with local periarticular injections: A prospective randomized study. The Journal of Arthroplasty. 2007;**22**(suppl 2):33-38

[53] keuchi M, Kamimoto Y, Izumi M, et al. Effects of dexamethasone on local infiltration analgesia in total knee arthroplasty: A randomized controlled trial. Knee Surgery, Sports Traumatology, Arthroscopy. 2014;**22**:1638-1643

[54] Sean VW, Chin PL, Chia SL, et al. Single-dose periarticular steroid infiltration for pain management in total knee arthroplasty: A prospective, double-blind, randomised controlled trial. Singapore Medical Journal. 2011;**52**:19-23

[55] Yue DB, Wang BL, Liu KP, Guo WS. Efficacy of multimodal cocktail periarticular injection with or without steroid in total knee arthroplasty. Chinese Medical Journal. 2013;**126**:3851-3855

[56] Kwon SK, Yang IH, Bai SJ, Han CD. Periarticular injection with corticosteroid has an additional pain management effect in total knee arthroplasty. Yonsei Medical Journal. 2014;**55**:493-498

[57] Christensen CP, Jacobs CA, Jennings HR. Effect of periarticular corticosteroid injections during total knee arthroplasty. A double-blind randomized trial. Journal of Bone and Joint Surgery. American Volume. 2009;**91-A**:2550-2555

[58] Chia SK, Wernecke GC, Harris IA, et al. Peri-articular steroid injection in total knee arthroplasty: A prospective, double blinded, randomized controlled trial. The Journal of Arthroplasty. 2013;**28**:620-623

[59] Tsukada S, Wakui M, Hoshino A. The impact of including corticosteroid in a periarticular injection for pain control after total knee arthroplasty. Bone & Joint Journal. 2016;**98-B**:194-200

[60] De Oliveira GS Jr, Almeida MD, Benzon HT, McCarthy RJ. Perioperative single dose systemic dexamethasone for postoperative pain: A meta-analysis of randomized controlled trials. Anesthesiology. 2011;**115**(3):575-588

[61] Kardash KJ, Sarrazin F, Tessler MJ, Velly AM. Single-dose dexamethasone reduces dynamic pain after total hip arthroplasty. Anesthesia and Analgesia. 2008;**106**:1253-1257

[62] Koh IJ, Chang CB, Lee JH, Jeon YT, Kim TK. Preemptive low-dose dexamethasone reduces postoperative emesis and pain after TKA: A randomized controlled study. Clinical Orthopaedics and Related Research. 2013;**471**:3010-3020

[63] Matsueda M, Gustilo RB. Subvastus and medial parapatellar approaches in total knee arthroplasty. Clinical Orthopaedics and Related Research. 2000;**371**:161-168

[64] Ejaz A, Laursen AC, Kappel A, et al. Faster recovery without the use of a tourniquet in total knee arthroplasty. Acta Orthopaedica. 2014;**85**:422-426

[65] Tsukada S, Wakui M, Hoshino A. Pain control after simultaneous bilateral total knee arthroplasty: A randomized controlled trial comparing periarticular injection and epidural analgesia. Journal of Bone and Joint Surgery: American Volume. 2015;**97-A**:367-373

[66] Yadeau JT, Goytizolo EA, Padgett DE, et al. Analgesia after total knee replacement: Local infiltration versus epidural combined with a femoral nerve blockade: A prospective, randomised pragmatic trial. Bone & Joint Journal. 2013;**95-B**:629-635

[67] Horan TC, Gaynes RP, Martone WJ, Jarvis WR, Emori TG. CDC definitions of nosocomial surgical site infections, 1992: A modification of CDC definitions of surgical wound infections. Infection Control and Hospital Epidemiology. 1992;**13**:606-608

[68] Reisine T, Pasternak G. Opioid analgesics and antagonists. In: Hardman JG, Limbard LE, editors. Goodman and Gilman's the Pharmacologic Basis of Therapeutics. 9th ed. New York: McGraw-Hill; 1996. p. 521

[69] Pulos N, Sheth N. Perioperative pain management following total joint arthroplasty. Annals of Orthopedics and Rheumatology. 2014;**2**(3):1029

[70] Azam MQ, Sadat-Ali M, Bader A. Pain management in knee arthroplasty: An overview. International Journal of Surgery Research and Practice. 2015;**2**:035

[71] Ahdieh H, Ma T, Babul N, Lee D. Efficacy of oxymorphone extended release in postsurgical pain: A randomized clinical trial in knee arthroplasty. Journal of Clinical Pharmacology. 2004;**44**:767-776

[72] Cheville A, Chen A, Oster G, McGarry L, Narcessian E. A randomized trial of controlled-release oxycodone during inpatient rehabilitation following unilateral total knee arthroplasty. Journal of Bone and Joint Surgery. American Volume. 2001;**83-A**(6):915

[73] Rathmell JP, Pino CA, Taylor R, Patrin T, Viani BA. Intrathecal morphine for postoperative analgesia: A randomized, controlled, dose-rangingstudyafterhipandknee arthroplasty. Anesthesia and Analgesia. 2003;**97**(5):1452-1457

[74] Gupta A. Update on intra-articular analgesia. Techniques in Regional Anesthesia and Pain Management. 2003;**7**(3):155-160

[75] Andrieu G, Roth B, Ousmane L, et al. The efficacy of intrathecal morphine with or without clonidine for postoperative analgesia after radical prostatectomy. Anesthesia and Analgesia. 2009;**108**(6):1954-1957

[76] Gürkan Y, Canatay H, Özdamar D, Solak M, Toker K. Spinal anesthesia for arthroscopic knee surgery. Acta Anaesthesiologica Scandinavica. 2004;**48**(4):513-517

[77] Bailey PL, Stanley TH. Pharmacology of intravenous narcotic aneshhetics. In: Miller RP, editor. Anesthesia. New York, NY, USA: Churchill Livingstone; 1986. pp. 745-797

[78] Gustafsson LL, Hallin ZW. Spinal opioid analgesia. A criticalupdate. Drugs. 1988;**35**(6): 597-603

[79] Kilickaya R, Orak Y, Balci MA, Balci F, Unal I. Comparison of the effects of intrathecal fentanyl and intrathecal morphine on pain in elective total knee replacement surgery. Pain Research & Management. 2016;**2016**:3256583

[80] Musclow SL, Bowers T, Vo H, Glube M, Nguyen T. Long-acting morphine following hip or knee replacement: A randomized, double-blind, placebo-controlled trial. Pain Research and Management. 2012;**17**(2):83-88

[81] Cheville A, Chen A, Oster G, McGarry L, Narcessian E. A randomized trial of controlled-release oxycodone during inpatient rehabilitation following unilateral total knee arthroplasty. The Journal of Bone and Joint Surgery. American Volume. 2001;**83**:572-576

[82] Illgen R, Pellino T, Gordon D, Butts S, Heiner J. Prospective analysis of a novel long-acting oral opioid analgesic regimen for pain control after total hip and knee arthroplasty. The Journal of Arthroplasty. 2006;**21**:814-820

[83] Kerpsack J, Fankhauser R. The use of controlled-release versus scheduled oxycodone in the immediate postoperative period following total joint arthroplasty. Orthopedics. 2005;**28**:491-494

[84] Rosner H, Rubin L, Kestenbaum A. Gabapentin adjunctive therapy in neuropathic pain states. The Clinical Journal of Pain. 1996;**12**:56-58

[85] Backonja M, Beydoun A, Edwards KR, et al. Gabapentin for the symptomatic treatment of painful neuropathy in patients with diabetes mellitus: A randomized controlled trial. Journal of the American Medical Association. 1998;**280**:1831-1836

[86] Buvanendran A, Kroin JS, Della Valle CJ, Kari M, Moric M, Tuman KJ. Perioperative oral pregabalin reduces chronic pain after total knee arthroplasty: A prospective, randomized, controlled trial. Anesthesia and Analgesia. 2010;**110**:199-207

[87] Orak Y, Gunes Y, Bicer S, Ozcengiz D. The effect of gabapentin on postoperative pain and opioid-related side effects in patients undergoing combined spinal-epidural anaesthesia (a preliminary study). Clinical and Experimental Medical Sciences. 2013;**1**(6):251-261

[88] Türktan M, Orak Y, Yasemin G, Sunkar Biçer Ö, Güleç E, Hatipoğlu Z, Burgut R. The effect of pregabalin on postoperative pain in the patients undergoing lower extremity surgery. Turkiye Klinikleri Journal of Anesthesiology. 2014;**12**(1):26-30

[89] Han C, Li X-d, Jiang H-g, Ma J-x, Ma X-l. The use of Gabapentin in the management of postoperative pain after total knee arthroplasty. A PRISMA-compliant meta-analysis of randomized controlled trials. Medicine. 2016;**95**:23

[90] Li F, Ma J, Kuang M, Jiang X, Wang Y, Lu B, Zhao X, Sun L, Ma X. The efficacy of pregabalin for the management of postoperative pain in primary total knee and hip arthroplasty: A meta-analysis. Journal of Orthopaedic Surgery and Research. 2017;**12**:49. DOI: 10.1186/s13018-017-0540-0

[91] Cengiz P, Gokcinar D, Karabeyoglu I, Topcu H, Cicek GS, Gogus N. Intraoperative low-dose ketamine infusion reduces acute postoperative pain following total knee replacement surgery: A prospective, randomized double-blind placebo-controlled trial. Journal of the College of Physicians and Surgeons–Pakistan. 2014;**24**:299-303

[92] Webb JM, Williams D, Ivory JP, Day S, Williamson DM. The use of cold compression dressings after total knee replacement: A randomized controlled trial. Orthopedics. 1998;**21**:59-61

[93] Angulo DL, Colwell CW Jr. Use of postoperative TENS and continuous passive motion following total knee replacement. Journal of Orthopaedic and Sports Physical Therapy. 1990;**11**:599-604

[94] Adie S, Kwan A, Naylor JM, Harris IA, Mittal R. Cryotherapy following total knee replacement. Cochrane Database of Systematic Reviews. 2012;**9**:CD007911

[95] Craig TH. Multimodal postopertive pain management. American Journal of Health-System Pharmacy. 2004;**61**:4-10

[96] Niv D, Lang DE, Devor M. The effect of preemptive analgesia on subacute postoperative pain. Minerva Anestesiologica. 1999;**65**:127-140

[97] Kissin I. Preemptive analgesia. Anesthesiology. 2000;**93**:1138-1143

[98] Katz J. Preemptive analgesia: Evidence, current status and future direction. European Journal of Anaesthesiology. 1995;**12**:8-13

[99] Melzac R, Casey KL. Sensory, motivational and central control determinants of pain. In: Kenshalo DR, editor. Skin Senses. New York: Springfield, IL; 1968. pp. 423-435

[100] Giraudet-Le Quintrec JS, Coste J, Vastel L, Pacault V, Jeanne L, et al. Positive effect of patient education for hip surgery: A randomized trial. Clinical Orthopaedics and Rela ted Research. 2003:112-120

[101] Demir H. Diz Artroplasti Rehabilitasyonu. Erciyes Tıp Derg. 2002;**24**:194-201

[102] Zeni JA Jr, Snyder-Mackler L. Early postoperative measures predict 1- and 2-year outcomes after unilateral total knee arthroplasty: Importance of contralateral limb strength. Physical Therapy. 2010;**90**:43-54

IntechOpen

IntechOpen