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Anesthetic and Analgesic Management for Outpatient Knee Arthroplasty

Chris Cullom[1] · **Jonathan T. Weed**[1]

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Abstract
Purpose of Review Total knee arthroplasty traditionally has been associated with significant postoperative pain that can limit recovery and prolong hospital length of stay. Recently, however, due to financial pressures and an emphasis on improving patient satisfaction, many institutions are implementing outpatient and short-stay programs for patients undergoing this procedure. An effective perioperative anesthetic plan is an essential quality of a successful outpatient joint replacement program.
Recent Findings Improved technology and innovation has led to more effective and efficient strategies that contribute to a smoother and quicker postoperative course. The use of peripheral nerve blocks in conjunction with a variety of systemic analgesics has reduced post-operative pain compared to older modalities. Specifically, the adductor canal and IPACK blocks have become increasingly popular due to their analgesic efficacy and muscle sparing characteristics.
Summary Outpatient knee arthroplasty is becoming a reality with advancements in surgical pathways that incorporate these newer modalities with an emphasis on multidisciplinary coordination.

Keywords Outpatient total knee arthroplasty · Multimodal analgesia · Adductor canal block · IPACK block · Regional anesthesia

This article is part of the Topical Collection on *Other Pain*

✉ Jonathan T. Weed
jweed@tulane.edu

[1] Department of Anesthesiology, Tulane University School of Medicine, 1430 Tulane Ave, SL-4, New Orleans, LA 70112, USA

Introduction

Total knee arthroplasty (TKA) is a surgical procedure with many anesthetic and analgesic challenges. Historically, TKA has been associated with a significant level of postoperative pain, which can be especially detrimental given the importance that early mobility has on long-term outcomes [1]. Inadequate control of pain after this procedure combined with poor mobility limits recovery and rehabilitation, which lengthens hospital stay and increases the financial burden upon the health care system. In addition, poor pain control increases reliance on opioids and contributes to nausea, vomiting, and decreased intestinal motility, potentially delaying discharge as well. Typically, patients undergoing TKA remain in the hospital for two to three days postoperatively. However, with improvements in surgical technique, coupled with a greater variety of analgesic options, some orthopedic surgery centers and hospitals are discharging patients on postoperative day one, and in some cases, on the same day. Keys to a successful outpatient TKA program include careful patient selection, good communication with the patient, effective coordination among the various providers, an ability to provide early physical therapy (PT) and other postoperative needs on an outpatient basis, and a robust and multifaceted analgesic strategy [2, 3•].

The decision to discharge a patient on the day of surgery following TKA is multifactorial and ultimately is made by the surgeon. However, the anesthesiologist plays a critical role in this endeavor. Factors influenced by the anesthetic plan that most commonly prolong hospital stay after TKA include poorly controlled pain, limited mobility, nausea, vomiting, and urinary retention. These factors can be mitigated by the use of a multimodal analgesic strategy. Regional anesthesia, when used in conjunction with opioid and non-opioid systemic analgesics, can help provide a more comfortable

postoperative course and reduce the side effects commonly associated with high-dose opioids used in isolation.

Regional anesthesia techniques traditionally used for TKA include epidurals, as well as femoral and sciatic peripheral nerve blocks. While these techniques all offer excellent analgesia, they have the disadvantage of causing significant muscle weakness in the affected areas. In order to achieve the goal of early discharge, patients must be able to ambulate comfortably, yet effectively, and must also avoid falls. Thus, any modality that inhibits muscle function is less than ideal for this patient population. Recently, adductor canal blocks have started to replace femoral blocks, as this technique can provide similar analgesic results while avoiding the quadriceps muscle weakness associated with femoral blocks. An even newer technique has also emerged called the IPACK, which has been used in some centers to replace sciatic blocks to cover posterior knee pain experienced by many TKA patients, without affecting function of the lower leg and foot. When combined with a regimen of low-dose oral and parenteral opioids, if needed, as well as non-opioid analgesics perioperatively, many patients can be comfortable and mobile enough for discharge home within a matter of hours.

Anesthetic Technique

Neuraxial techniques such as epidural or spinal anesthesia are widely used for total knee arthroplasty and offer advantages compared to general anesthesia (GA), including a reduced 30-day mortality, lower frequency of blood transfusion, and fewer superficial wound infections. [4–7] Additionally, GA also carries the risks associated with airway manipulation, as well as a higher likelihood of respiratory and hemodynamic complications. When compared to neuraxial anesthesia, GA was found to have an increased risk of postoperative ventilator usage, unplanned intubation, stroke, and cardiac events based on a NSQiP database retrospective study. [8] Also important to consider is the effect of GA on postoperative cognitive function and delirium, which can be a significant factor of delayed discharge, especially among older patients. [9] Neuraxial anesthesia is of course not without adverse events as well, which include epidural hematoma, epidural abscess, hypotension, and urinary retention. [10, 11] While there are contradictions in the literature, with various types of reports and studies often reaching conflicting conclusions, the advantages of neuraxial anesthesia for TKA tends to outweigh those of GA, especially given the push to shorten hospital length of stay. Most recently, a 2016 meta-analysis of 29 studies including 10,488 patients reported that neuraxial anesthesia had a significantly shorter length of stay compared to GA. [12] Both neuraxial and general anesthesia are reasonable options for TKA, and while a successful outpatient program could incorporate either modality, the literature suggests that avoiding GA in favor of a neuraxial technique would improve success.

Femoral and Sciatic Blocks

The widespread use of ultrasound to advance peripheral nerve block techniques over the past decade has led to enormous growth in the utilization and efficiency of regional anesthesia. Numerous studies have reported on the effectiveness of nerve blocks to reduce the consumption of postoperative opioids, in effect leading to a significant reduction in all opioid-related complications and side effects, such as nausea, vomiting, urinary retention, pruritus, gastric motility, and respiratory depression. Specifically among patients undergoing TKA, Chan et al. reported in a meta-analysis that femoral nerve blocks offered superior analgesia, fewer side effects, and greater knee flexion postoperatively compared to patient controlled analgesia. [13] Additionally, sciatic blocks, performed either in the gluteal, subgluteal, or popliteal regions, can be a useful adjunct along with femoral blocks to provide analgesia to the posterior aspect of the knee. A meta-analysis consisting of 900 patients found that sciatic nerve block combined with femoral nerve block had significantly lower pain scores compared to femoral nerve block alone. [14].

However, despite the strong evidence that these techniques offer superior analgesia over opioids alone, concerns exist regarding their potential roles in contributing to postoperative falls. [15, 16] While there is no denying that femoral and sciatic blocks cause profound muscle weakness in the quadriceps and lower leg, respectively, the data on their potential causative effects on patient falls is conflicting [17, 18]. For example, Ilfeld et al. pooled data from three randomized trials and found a casual link between peripheral nerve block, quadriceps weakness, and falls in knee and hip arthroplasty patients. [16] However, Memtsoudis et al. performed a retrospective study of 191,570 patients undergoing knee arthroplasty and found there to be no significant association between inpatient falls and peripheral nerve blocks. The argument can be made that avoiding blocks (and thus relying on heavier doses of narcotics for analgesia) creates a postoperative environment that is equally unsafe for ambulation. Regardless, in a patient population in which early ambulation is critical, neither high-dose opioids nor weakness-inducing nerve blocks are ideal. [19, 20].

Adductor Canal Block

The adductor canal block (ACB) was developed with the intention to provide analgesia to patients undergoing knee surgery while preserving quadriceps muscle function, and it has

been gaining in popularity over the past few years. The adductor canal is the anatomic space located within the middle third of the thigh that is bordered anteriorly by the sartorius muscle, posteriorly and medially by the adductor longus and magnus muscles, and laterally by the vastus medialis muscle (Fig. 1). The "canal" that is formed by these muscle borders contains the femoral vein and artery, as well as the saphenous nerve and the nerve to the vastus medialis, both sensory branches of the femoral nerve. In some individuals, the obturator sensory branch is also in close enough proximity to be affected by local anesthetic infiltration into this area. [21] By targeting this specific space, the adductor canal block can anesthetize sensory branches and yet avoid blocking the majority of motor branches that supply the muscles of the leg. The block is most commonly performed using ultrasound guidance. With the probe placed on the anteromedial aspect of the mid-thigh, the femoral artery, vein, and bordering muscles are identified, and 10–30 ml of local anesthetic is injected in the fascial space next to the saphenous nerve, which typically resides on the anterolateral aspect of the superficial femoral artery. [21–23].

A major question that naturally needs answering is whether the analgesia obtained from this injection is comparable to a femoral block, which in theory should block most, if not all, of these branches in a single shot (along with the motor branches as well). Several studies have examined this very question with results that surprisingly suggest that postoperative analgesia is not significantly different when TKA patients are randomized to receive a femoral block versus ACB. Not surprisingly, patients receiving an ACB consistently demonstrate superior motor function postoperatively, and are thus able to engage more rigorously with physical therapy on post-op days 0–2. [23, 24] Adductor canal blocks have therefore become an appealing option as they can enhance the patient's ability to participate in physical therapy rehabilitation and potentially avoid postoperative falls due to reduced quadriceps weakness. (It is important to note that quadriceps weakness is not avoided completely, as the surgery itself can affect muscle strength, even in patients who receive no block at all.) These qualities have allowed the adductor canal block to gradually replace the femoral nerve block as the primary analgesic technique for total knee arthroplasty. [22].

IPACK Block

Pain in the posterior aspect of the knee can be a significant issue for patients after TKA, as this area is not covered by femoral or adductor canal blocks. While a sciatic block provides excellent coverage of this area, it also produces a profound motor block of the lower leg and foot. Patients exhibiting a "foot drop" postoperatively as a result of a nerve block are less able to engage in physical therapy. Additionally, there is concern that this motor block may mask the symptoms of a surgical injury to the peroneal nerve. Infiltration of local anesthetic into the Interspace between the Popliteal Artery And posterior Capsule of the Knee (IPACK) is a newer block that has shown promise for patients undergoing knee surgery. The IPACK block is a simple procedure that provides effective analgesia of the posterior capsule of the knee while preserving motor function, and has emerged as a convenient alternative to sciatic blocks. Best performed under ultrasound guidance, the needle is advanced to the space located between the popliteal artery and the poster knee (Fig. 2). The combination of a single injection IPACK block with an adductor canal continuous catheter was demonstrated to provide analgesia to TKA patients that is comparable to a femoral-sciatic combination, with less motor weakness, significantly improved physical

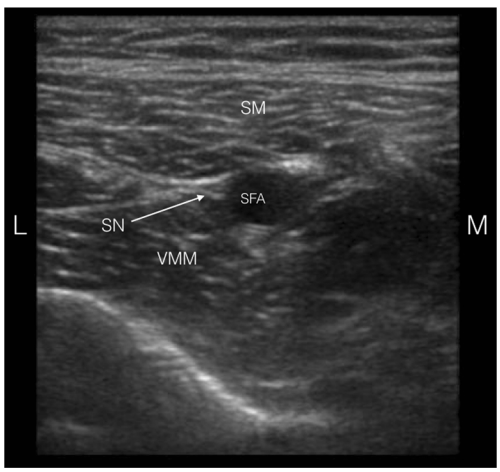

Fig. 1 Ultrasound image of the adductor canal. Local anesthetic should be deposited near the saphenous nerve (SN). VMM: Vastus medalis muscle. SM: Sartorius muscle. SFA: Superficial femoral artery. L: Lateral. M: Medial

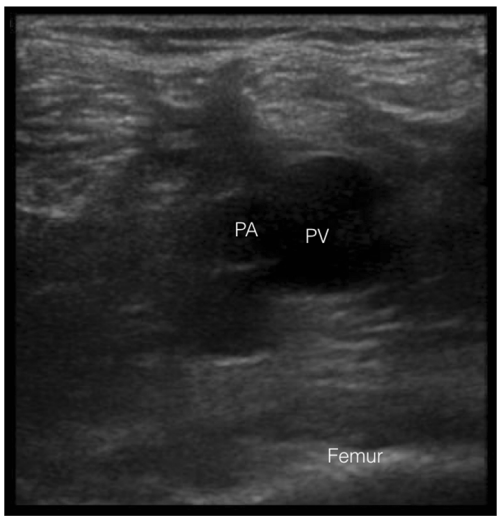

Fig. 2 Ultrasound image of the IPACK block. Local anesthetic should be deposited in the space between the popliteal vessels (PA: Popliteal artery, PV: Popliteal vein) and the distal femur

therapy performance, and reduced hospital length of stay. [25–28].

Local Infiltration

Another popular analgesic modality is local anesthetic infiltration (LAI) by the surgeon directly into the operative site. A typical mixture might contain bupivacaine or ropivacaine, morphine, ketorolac, and occasionally epinephrine. The solution is injected into the posterior capsule, collateral ligaments, capsular incision, quadriceps tendon, and subcutaneous tissue. Combination of ACB with local infiltration compared to ACB alone has shown lower pain scores with the combination group. However, it has not been demonstrated whether LAI by the surgeon is a more effective technique than IPACK block. This may prove to be difficult to determine globally, as there exists significant variability in technique and contents of the injection [29•].

Multimodal Analgesia

A preoperative regimen of oral analgesics can be a useful method of providing analgesia while also reducing the overall doses of any individual medication. Particularly problematic is the use of opioids, especially in high doses, as they are associated with dose-dependent side effects that can be detrimental to recovery after TKA. Acetaminophen, a COX2 inhibitor (such as celecoxib), and gabapentin are examples of non-opioid analgesics that can reduce the amount of opioids needed postoperatively to provide adequate pain control. There is also evidence that these medications given preemptively before incision, especially in conjunction with peripheral nerve blocks, neuraxial anesthesia, and moderate doses of opioids, will offer even greater value than analgesics given as needed after surgery. [30, 31] An effective multimodal analgesia protocol starts in the preoperative phase with education about the procedure, a description of potential pain levels and side effects, and a discussion about the risks and benefits of all of the various anesthetic and analgesic options. This is important, as it establishes realistic expectations by the patient and allows them to be actively engaged in the perioperative plan. A reasonable preoperative oral regimen might include 1000 mg of acetaminophen, 400 mg of celecoxib, 300-600 mg of gabapentin, and 10-20 mg of oxycontin. Peripheral nerve blocks are also important components of multimodal analgesia and work best when performed preemptively prior to surgery. Intraoperatively, spinal anesthesia with IV sedation offers more analgesic benefit than general anesthesia. Postoperatively, continued administration of oral acetaminophen, COX2 inhibitors, and opioids, in conjunction with a continuous nerve block, can effectively reduce or even eliminate the need for intravenous opioids. This regimen employs a variety of different analgesic methods to avoid reliance on and overuse of a single opioid. [32].

Outpatient Total Knee Arthroplasty

Multiple factors contribute to the trend of steadily decreasing hospital length of stay over the past 2–3 decades for nearly all surgical procedures. Growing pressure on hospitals to reduce cost, advancements in surgical techniques, development of enhanced recovery protocols, and more effective analgesia options are all factors that contribute to a significant reduction in length of stay for patients recovering from surgical procedures such as TKA. While TKA is not yet routinely performed on an outpatient basis, several published reports of "fast-track" programs have emerged in recent years. These reports demonstrate the feasibility of performing knee replacement surgery on an outpatient basis (or with next-day discharge), but they also emphasize the importance of a well-designed plan. Berger et al. demonstrated the practicality of outpatient total knee arthroplasty. Of note, a unicompartmental knee arthroplasty was used, not the traditional total knee arthroplasty. Using a multimodal analgesic approach, discharge of total knee arthroplasty on POD1 is a realistic possibility and same day discharge is feasible using a less invasive surgical approach. [2, 33, 34].

Surgical pathways involving preoperative teaching, adductor canal blocks, and early initiation of physical therapy on the day of surgery have shown decreased length of stay and even same-day discharges without readmissions. Comprehensive pathways have proven to be feasible approaches to speed discharge with similar pain control and patient satisfaction. Use of a continuous adductor canal catheter in the post-discharge phase also shows promise as the next step in knee arthroplasty pain management allowing for shorter lengths of stay [3•, 35••].

A successful outpatient TKA program requires a multidisciplinary approach with good communication and coordination between the surgeons, anesthesiologists, nurses, physical therapists, and social workers. There are several issues outside the control of the anesthesia team that can cause delay in hospital discharge, such as postoperative surgical complications, logistical delays, and social challenges. However, two of the most common barriers to an early discharge for TKA patients include inadequate pain control and limited mobility, both of which are heavily influenced by the anesthetic and analgesic plan. By incorporating techniques that offer excellent pain control while also limiting the unwanted effects of nausea, sedation, confusion, and muscle weakness,

anesthesiologists can play a vital role in the movement towards early discharge for patients undergoing TKA. [36].

Conclusions

Postoperative pain and mobility remains a vital component affecting patient satisfaction, PT participation, and discharge readiness. Choosing the right anesthetic modality for knee arthroplasty can significantly reduce pain and mobility, and thus have a dramatic impact on the postoperative course. Discharge after knee arthroplasty is a multifactorial decision, however adequate pain control and ambulation are key factors that guide the decision. These two characteristics allow for earlier participation in physical rehabilitation and preserve functional status in the outpatient phase. Avoiding postoperative complications such as nausea, vomiting, urinary retention, and poor mobility is just as important as providing adequate pain control. Both goals can be accomplished through the application of a multimodal approach to analgesia, including oral medications in conjunction with neuraxial and peripheral regional anesthetic techniques. The expanded use of ultrasound has allowed for the rapid growth in the number of anesthesiologists who are able to learn and perform peripheral nerve blocks successfully. As a result, the use of general anesthesia followed by an intravenous opioid as the sole analgesic modality is no longer the standard of care. In fact, given the information and technology available today, that approach should be dismissed as outdated and inadequate. The fact that the femoral nerve block, just recently the gold standard for analgesia and still in use by many providers, is already being replaced with the ACB is a testament to the rapid innovation that exists in our field today. Numerous external pressures drive this innovation, including the emphasis on reducing costs through shorter hospital stays and improving patient satisfaction, which is increasingly being tied to reimbursement. Allowing patients to return home sooner, or to an outpatient-based rehabilitation center, will improve those metrics. The anesthesiologist plays a critical role in ensuring that the patient will be ready for discharge, but must be engaged in the entire perioperative process. The use of a surgical pathway provides a clear track to early discharge, but is only effective when all members of the team coordinate and communicate well.

Compliance with Ethics Guidelines

Conflict of Interest Chris Cullom and Jonathan T. Weed declare that they have no conflicts of interest.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

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Papers of Particular Interest, published recently, have been highlighted as:
- • Of importance
- •• Of major importance

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