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ADDUCTOR CANAL BLOCK VERSUS FEMORAL NERVE BLOCK IN TOTAL KNEE
ARTHROPLASTY

by

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Bachelor of Science in Nursing, North Dakota State University, 2015

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Master of Science

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PERMISSION

Title Adductor Canal Block Versus Femoral Nerve Block in Total Knee
Arthroplasty
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ABSTRACT

Title: Adductor Canal Block Versus Femoral Nerve Block in Total Knee Arthroplasty

Background: Within the United States there are approximately 670,000 total knee arthroplasties conducted each year (Wang et al., 2017). Femoral nerve blocks have been considered a standard therapy in patients undergoing total knee arthroplasties (Koh et al. , 2017). Although femoral nerve blocks have been shown to provide excellent postoperative analgesia, it does have a downside, quadricep weakness. For this reason, an adductor canal block may be the answer.

Purpose: The purpose of this literature review is to compare the utilization of an adductor canal block in patients undergoing total knee arthroplasty and how this particular block compares to a femoral nerve block in terms of postoperative quadricep strength, ambulation, analgesia, and opioid consumption.

Process: A literature search was performed using the University of North Dakota's Health Sciences Library, resulting in eleven journal articles published within approximately the past five years being selected for review.

Results: A review of the literature found adductor canal blocks utilized for total knee arthroplasty consistently provided comparable analgesia when compared to a femoral nerve block. However, the adductor canal block results in superior quadricep strength and earlier ambulation (Kim et al., 2014).

Implications: Given the comparable level of analgesia and superior quadriceps strength and potential for earlier ambulation, anesthesia professionals may consider utilizing an adductor canal block for patients undergoing total knee arthroplasty.

Keywords: total knee arthroplasty, adductor canal block, femoral nerve block, postoperative pain, quadricep weakness

Adductor Canal Block Versus Femoral Nerve Block in Total Knee Arthroplasty

There are approximately 670,000 total knee arthroplasties conducted each year in the United States, and with our aging population growing this figure is likely to increase (Wang et al., 2017). Postoperatively a total knee arthroplasty is associated with severe pain in over 50% of patients, impacting their ability to participate in mobility exercises, and thus delaying discharge (Wang et al., 2017). As the trend in hospitals is to shorten patients' length of stay while also controlling postoperative pain while sparing opioid administration, femoral nerve blocks have been considered a standard therapy in patients undergoing total knee arthroplasties (Koh et al., 2017).

Although femoral nerve blocks have been shown to provide excellent postoperative analgesia for patients, it may cause quadricep weakness. Subsequently, patients may be unable to participate in early ambulation while also having an increased risk of falls, both of which could lead to an extended hospital stay (Koh et al., 2017). Although postoperative pain control is paramount, Hegazy & Sulta (2015) states that, "the ideal nerve block for a total knee arthroplasty should provide effective analgesia while preserving the muscle power to expedite recovery" (p. 124). For this reason, an adductor canal block may be the answer.

Purpose

The purpose of this literature review is to extensively compare the utilization of an adductor canal block in patients undergoing total knee arthroplasty and how this particular block compares to a femoral nerve block in terms of postoperative quadricep strength, ambulation, analgesia, and opioid consumption. This issue requires reviewing as functional recovery is essential and is directly impacted by postoperative pain (Kim et al., 2014). Femoral nerve blocks have been found to "provide superior analgesia and a decrease in hospital stay in comparison to

epidurals and patient-controlled analgesia alone” (p. 540) in patients undergoing total knee arthroplasty but is associated with prolonged motor blockade (Kim et al, 2014). According to Jaeger et al. (2013), “a study in healthy volunteers showed that a femoral nerve block reduced quadriceps strength by forty-nine percent from baseline” (p. 526). With this prolonged motor blockade patients who are administered a femoral nerve block suffer from quadricep weakness which is associated with a fall risk of two percent (Kim et al., 2014). Quadricep weakness may also prolong patients’ length of stay and their ability to participate in physical therapy.

Kim et al. (2014) describe the ideal nerve block for total knee arthroplasty as providing adequate analgesia, reducing the need for opioids, and not effecting motor strength. “Motor preservation with adequate analgesia has become the optimal postoperative pain goal in orthopedic surgeries to enable earlier physical therapy, faster recovery, and shorter hospital stays” (Kim et al., 2014, p. 540). For this reason, anesthesia professionals have begun to utilize the adductor canal block more frequently as it provides primarily a sensory blockade (Li & Ma, 2016). The question is though, can an adductor canal block provide similar postoperative analgesia with improved quadricep strength and ambulation in comparison to a femoral nerve block. It is hypothesized by Kim et al. (2014) that “an adductor canal block, compared with a femoral nerve block, would exhibit less quadricep weakness and demonstrate noninferior pain scores and opioid consumption” (p. 540).

Case Report

A 41-year-old, 175 cm, 99 kg male presented to undergo a right total knee arthroplasty as a result of osteoarthritis of the right knee. Past medical history included hypertension, hyperlipidemia, asthma, gastroesophageal reflux, hypothyroidism, osteoarthritis, bipolar, and schizoaffective disorder. The patient’s hypertension, asthma, and gastroesophageal reflux were

well controlled. Past surgery history included a hernia repair, appendectomy, cholecystectomy, shoulder arthroplasty, and knee arthroplasty. During a previous surgery, the patient did experience a complication of aspiration. However there had been no reoccurrence of this event in subsequent surgeries. Current medications included trazodone, diphenhydramine, fluticasone, verapamil, clozapine, hydroxyzine, acetaminophen, divalproex sodium, and albuterol. His allergies included bee stings, pemoline, trimethoprim, and mupirocin.

A preanesthetic evaluation found no additional health concerns other than those listed in his chart. An airway assessment revealed a Mallampati class three, thyromental distance of three fingerbreadths, mouth opening greater than three fingerbreadths, and full neck range of motion. Preoperative vital signs included blood pressure 140/91 mmHg, heart rate 101 min, respiratory rate 16 min, oxygen saturation 96% on room air, and temperature 36.7 degrees Celsius. The patient was given an American Society of Anesthesiologists physical status classification of two. After consultation with the patient and surgeon, it was decided he would receive a spinal with intravenous sedation intraoperatively. Postoperatively, an adductor canal block would be placed in the post-anesthesia care unit.

An 18-gauge peripheral intravenous catheter was placed in the patient's right hand preoperatively and a Lactated Ringers (LR) infusion was initiated. Acetaminophen 1 g, omeprazole 20 mg, gabapentin 600 mg, and tramadol 100 mg were administered orally. He was then transferred to preoperative holding, before being transferred to the operating room.

Once in the operating room, the patient was transferred over to the operating table and positioned in the seated position. Standard monitoring equipment was connected, consisting of a five-lead electrocardiogram, pulse oximetry, blood pressure cuff, and temperature probe. After vital signs were taken and deemed to be close to the patient's baseline, he was prepped for

placement of the spinal anesthetic. Oxygen at 4 L/min via nasal cannula was applied, along with midazolam 2 mg and fentanyl 75 mcg administered intravenously. In addition, the patient was administered an LR bolus of 500 ml, along with cefazolin 2 g.

He was then instructed to arch his back while hugging a pillow while a nurse supported the patient from the front, along with him being told to vocalize during the procedure if any pain, dizziness, and/or circumoral numbness was experienced. The patient was prepped and draped in the usual sterile fashion. The iliac crest was identified and the L3-L4 interspace selected as the spinal insertion site. A 25-gauge, 1-1/2 inch needle with lidocaine 1% was utilized to anesthetize the skin over the insertion site. An introducer needle was positioned, and a 25-gauge, 3-1/2 inch Pencan needle inserted until a “light pop” was felt. The stylet was removed, with positive identification of clear cerebral spinal fluid free flowing from the needle hub. A total of 1.8 ml of bupivacaine 0.75% in 8.75% dextrose was injected into the subarachnoid space. The needle and introducer were removed, and the patient positioned in the right lateral decubitus position for five minutes. The patient was then placed in the supine position, and the level of the block deemed adequate in regard to the loss of sensation and motor weakness, consistent with a T10 level block. As the patient was prepped for surgery a propofol infusion was started at 75 mcg/kg/min. On incision tranexamic acid 1 g was administered intravenously.

Altogether the patient tolerated the procedure well, with hypotension occurring once after the tourniquet was deflated. Phenylephrine 50 mcg was administered which resolved the hypotension. Following completion of the procedure, the propofol infusion was stopped and the patient was transferred to the post-anesthesia care unit without complication. The patient received 1300 ml of LR, with an estimated intraoperative blood loss of 200 ml.

In the post-anesthesia care unit pain and vital signs were assessed, prior to placement of the adductor canal block. The patient was placed in the supine position and the patient's right thigh prepped and draped in the usual sterile fashion. The ultrasound probe was placed in the transverse position over the anteromedial aspect of the mid-thigh, and used to first identify the femur, before moving medially and positively identifying the sartorius muscle, vastus medialis, adductor longus, saphenous nerve, and femoral artery. A 20-gauge, 100 mm insulated needle was inserted from lateral to medial in an in-plane relation to the ultrasound probe. Once the needle was in place negative aspiration was confirmed and 1 ml of ropivacaine 0.5% was injected to confirm needle placement. With placement confirmed a total of 25 ml of ropivacaine 0.5% was injected in 5 ml increments with negative aspiration occurring sequentially after each incremental 5 ml injection. The patient tolerated the adductor canal block well, with no complications.

After meeting post-anesthesia care unit transfer criteria, he was transferred to the floor. Over the next day the patient received acetaminophen 650 mg every six hours, ketorolac 15 mg once, oxycodone 5 mg once, and tramadol 50 mg twice. He was discharged later that day, after working with physical therapy, and meeting the hospital's discharge criteria.

Research Question

The formulation of a PICO question is vital to this literature review to ensure a precise direction for literature searching and reviewing. A PICO question allows the user to construct a clinical question that enables direction when reviewing literature. A PICO question contains four categories, these categories include (P) patient/population, (I) intervention/indicator, (C) comparison/control, and (O) outcome (New York University Division of Libraries, 2019). For the developed PICO question in this literature review, (P) represents surgical patients undergoing

a total knee arthroplasty, (I) adductor canal block, (C) femoral nerve block, and (O) postoperative quadricep strength, ambulation, analgesia, and opioid consumption. The development and revision of my PICO question lead to the completion of a specific and applicable research question which will advance evidence-based practice in the use of an adductor canal block in total knee arthroplasty. This question is: in surgical patients undergoing a total knee arthroplasty does an adductor canal block provide similar postoperative analgesia/opioid consumption with improved quadricep muscle strength/ambulation in comparison to a femoral nerve block?

Method Used for Literature Search

Resource Selection

A literature search was performed using the University of North Dakota's Health Sciences Library. Accessing this library provided a scholarly, reputable, and organized platform for finding relevant journal articles through the databases Clinical Key, Elsevier, PubMed, Sage, and Wolters Kluwer. These five databases were selected because like PubMed Central (2018) states, publishers are required to submit a formal application which must meet the database's requirements. The signing of an agreement with the National Library of Medicine allowing article review prior to publication is also required (PubMed Central, 2018). In addition, these databases also provide relevant journal articles for my PICO question as they contain journal articles which are focused on clinical practice, medical research, and life science.

Literature Search and Limitations

The key words used either individually or in combination during my literature search included (a) "total knee arthroplasty"; (b) "adductor canal block"; (c) "femoral nerve block"; (d) "postoperative pain" and (e) "quadricep weakness." The search was limited to journal articles

occurring in approximately the last 5 years and involved mostly the highest evidence available in the form of randomized controlled studies, retrospective studies, systematic reviews, and meta-analyses. These limitations were utilized to guarantee each literature search presented applicable, reliable, unbiased, and current articles for selection.

Article Search Results

The key words and discussed limitations imposed throughout the literature search, along with the review of applicable article reference sections resulted in over twenty relevant articles. Of those twenty plus journal articles, eleven were selected for review. The reasoning for the eleven journal articles being selected was because they were the most applicable towards my PICO question, void of data altering limitations, and were conducted using higher ranked levels of evidence based on the evidence pyramid in comparison to the journal articles excluded.

Discussion

Before performing a literature review of the selected articles, numerous topics need to be discussed to better comprehend the difference between an adductor canal block versus a femoral nerve block and why one may be more beneficial over the other in patients undergoing total knee arthroplasty. These topics include total knee arthroplasty, peripheral nerve blocks, the pain pathway, nerves, local anesthetics, lower extremity anatomy/innervation, and the adductor canal block.

Total Knee Arthroplasty

Total knee arthroplasty is a procedure performed for a variety of reasons, with osteoarthritis and rheumatoid arthritis being the most common (Tan et al., 2018). During a total knee arthroplasty, the surgeon removes cartilage from the articulating surfaces of the femur, tibia, and patella, allowing these surfaces to conform to the prosthetics being inserted (Nagelhout

& Elisha, 2018). After this process polymethylmethacrylate is placed on the femur and tibial articulating surfaces, and the prosthetics seated into position (Nagelhout & Elisha, 2018). Altogether a “total knee arthroplasty involves extensive bone resection and soft tissue manipulation, and patients can experience severe pain during the early postoperative period” (Koh et al., 2017, p. 87). This leads to the association of severe pain in over 50% of patients, potentially leading to decreased mobility, an increased fall risk, delayed discharge, and reduced patient satisfaction (Wang et al., 2017). In addition, according Jaeger et al. (2013) quadriceps muscle strength is reduced between sixty to eighty-three percent after a total knee arthroplasty.

Peripheral nerve blocks

Koh et al. (2017) states “peripheral nerve blocks have been used as a contemporary multimodal approach to pain control after total knee arthroplasty” (p. 87). Utilization of peripheral nerve blocks have many benefits such as a reduced risk of “nausea and vomiting, decreased postoperative pain, reduced bleeding, reduction in hospital length of stay, and improved patient satisfaction” (Nagelhout & Elisha, 2018, p. 1043). Although there are many beneficial aspects of regional anesthesia there are also some potential complications such as local anesthetic systemic toxicity, nerve injury, vascular injury, hematoma formation, and infection (Nagelhout & Elisha, 2018). There are also scenarios where the utilization of a peripheral nerve block is either relatively or absolutely contraindicated including, patient refusal, injection site infection, coagulopathy, inability to cooperative, and pre-existing neurologic conditions (Nagelhout & Elisha, 2018).

Pain Pathway

Pain is described by Nagelhout & Elisha (2018) as “an unpleasant sensory and emotional experience associated with actual or potential tissue damage or described in terms of such

damage” (p. 1167). Pain itself is a dynamic process, and its understanding is important to comprehend how peripheral nerve blocks achieve anesthesia and analgesia. The pain pathway is divided into four processes: transduction, transmission, modulation, and perception (Nagelhout & Elisha, 2018).

Transduction occurs when a pain receptor is exposed to a noxious stimulus whether it be mechanical, chemical, electrical, and/or thermal, resulting in the development of an action potential caused by an influx of sodium ions into the nerve (Nagelhout & Elisha, 2018). As this signal synapses with the dorsal horn transmission begins, with the pain signal transmitting to the anterolateral portion of the spinal cord through the tract of Lissauer (Nagelhout & Elisha, 2018). Following transmission, the next process modulation occurs, primarily working in the dorsal horn to either enhance or inhibit pain signals (Nagelhout & Elisha, 2018). Enhancement occurs for instance through central sensitization, increasing the pain level that is perceived (Nagelhout & Elisha, 2018). In contrast, inhibition of pain signals can occur as the descending pain pathway releases neurotransmitters such as norepinephrine, serotonin, and endogenous opioids (Nagelhout & Elisha, 2018). Finally, perception occurs in the cerebral cortex and limbic system, determining how the brain processes the pain signals received (Nagelhout & Elisha, 2018).

Neuron orders. The process from transduction to perception is further broken down into three neuron orders, first order, second order, and third order (Nagelhout & Elisha, 2018). First order neurons begin at free or specialized pain receptors and end in the dorsal horn (Nagelhout & Elisha, 2018). Second order neurons transmit these signals from the dorsal horn to the thalamus, and third order neurons consist of pain signals being sent from the thalamus to various areas of the brain such as the cerebral cortex and hypothalamus (Nagelhout & Elisha, 2018). Depending on the intervention utilized will determine which part of the pain pathway is being enhanced or

inhibited (Nagelhout & Elisha, 2018). For instance, local anesthetics, those used in peripheral nerve blocks, work on providing anesthesia and analgesia through interacting with the processes of transduction and transmission (Nagelhout & Elisha, 2018). Altogether understanding of the pain pathway allows for the comprehension of how different medications reduce pain, and why peripheral nerve blocks are an essential part of “current multimodal pain management protocol following total knee arthroplasty” (Koh et al., 2017, p. 87).

Nerves

To better understand peripheral nerve blocks, nerves themselves need to be understood. In peripheral nerves the axon is the functional unit of the nerve which is composed of an axolemma and axoplasm (Nagelhout & Elisha, 2018). Depending on the type of nerve, the axolemma and axoplasm may be encased by Schwann cells providing insulation, also known as myelination (Nagelhout & Elisha, 2018). The degree of myelination determines conduction along with the three differing types of nerve fibers, their function, and their diameters as it will determine how easily or how difficultly they are blocked (Nagelhout & Elisha, 2018). At the point of the nodes of Ranvier myelination is absent, allowing local anesthetics to exert their effect (Nagelhout & Elisha, 2018). In total, two to three nodes of Ranvier need to be blocked to prevent nerve conduction (Nagelhout & Elisha, 2018).

Before this effect can occur though, local anesthetics must diffuse across three connective tissue layers which support the nerve consisting of the endoneurium, perineurium, and epineurium (Nagelhout & Elisha, 2018). Resting membrane potential in nerves range from -70 to -90 millivolts and are maintained at this voltage by the sodium-potassium pump, pumping three sodium ions out of the cell for every two potassium ions pumped into the cell (Nagelhout & Elisha, 2018). With the stimulus of an electrical impulse to the nerve sodium ions influx into the

nerve cell causing depolarization (Nagelhout & Elisha, 2018). Once depolarization is complete, sodium channels close, and potassium influxes into the cell returning the nerve to its resting membrane potential (Nagelhout & Elisha, 2018).

Local Anesthetics

Local anesthetics exert their effect on nerves by reversibly binding to sodium channels and preventing the influx of sodium ions into the nerve (Nagelhout & Elisha, 2018). For binding to occur the nerve membrane must be either in its inactive or open state (Nagelhout & Elisha, 2018). When a local anesthetic is administered the medication's lipid soluble non-ionized portion diffuses into the interior of the cell, where the water-soluble ionized portion of the local anesthetic can exert its effect (Nagelhout & Elisha, 2018).

Local anesthetics are classified as either esters or amides (Nagelhout & Elisha, 2018). These two classes of medications vary from one another in terms of metabolism, their potential for allergic reactions, and their duration of action (Nagelhout & Elisha, 2018). For the purpose of this literature review, bupivacaine and ropivacaine will be discussed as these two medications were involved in the studies being reviewed. Both bupivacaine and ropivacaine are metabolized in the liver via cytochrome P450 1A2 and cytochrome P450 3A4 (Nagelhout & Elisha, 2018). They rarely initiate allergic reaction as they do not contain para-aminobenzoic acid as esters do (Nagelhout & Elisha, 2018). Finally, both medications have a long duration due to their lipophilic nature and high degree of protein binding (Nagelhout & Elisha, 2018).

As with all local anesthetics there is a maximum dosage guideline to prevent local anesthetic systemic toxicity which varies depending on the source. Nagelhout & Elisha (2018) recommends ropivacaine's maximum dose at 3 milligrams per kilogram, or 200 milligrams. As for bupivacaine, Nagelhout & Elisha (2018) recommends a maximum dosage ranging from 2-2.5

milligrams per kilogram, or 175-225 milligrams. Although these maximum local anesthetic dosages exist, it is important to know that even small amounts of local anesthetics administered into the intravascular space can result in local anesthetic systemic toxicity (Nagelhout & Elisha, 2018). As for the duration of action of ropivacaine and bupivacaine that will vary depending on the block being utilized and the concentration administered; this topic will be further covered when discussing the adductor canal block.

Lower Extremity Anatomy and Innervation

The femoral nerve arises from the lumbar nerve roots two through four (Nagelhout & Elisha, 2018). Motor and sensory innervation to the anterior thigh, anteromedial knee, and medial aspect of the lower leg can be attributed to the femoral nerve and the nerve distributions arising from it (Nagelhout & Elisha, 2018). As the femoral nerve descends inferiorly into the lower extremity it descends through the pelvis between the iliac and psoas muscles until reaching the inguinal ligament (Nagelhout & Elisha, 2018). At this point the femoral nerve is located lateral to the femoral artery as it continues inferiorly before splitting into an anterior and posterior division (Nagelhout & Elisha, 2018). The anterior branch of the femoral nerve provides motor innervation to the pectineus and sartorius muscles, with sensory innervation to the anterior surface of the thigh (Nagelhout & Elisha, 2018).

In contrast, the posterior branch of the femoral nerve provides motor innervation to the rectus femoris, vastus medialis, vastus intermedius, vastus lateralis, and articularis genus (Nagelhout & Elisha, 2018). The saphenous nerve provides the sensory innervation for the posterior branch of the femoral nerve and is responsible for the innervation of the “medial, anteromedial, and posteromedial aspects of the lower extremity from the distal thigh to the medial malleolus” (Farag & Mounir-Soliman, 2016, p. 147). This nerve, along with several

others can be seen bound by the anteromedial compartment of the thigh consisting of the “sartorius muscle above, the vastus medialis muscle laterally, and the adductor muscles medially” forming the adductor canal (Lim, Quek, Phoo, Mah, & Tan, 2018, p. 2).

Adductor Canal Block

“The adductor canal is located at the middle one third of the thigh and runs from the apex of the femoral triangle proximally to the adductor hiatus distally” (Li & Ma, 2016, p. 2617). Located in the adductor canal are the saphenous nerve along with the “medial femoral cutaneous nerve, medial retinacular nerve, articular branches from the obturator nerve,” and the nerve innervating the motor function of the vastus medialis, all which are blocked in an adductor canal block (Kim et al., 2014, p. 541). Due to this anatomy, according to Kim et al. (2014) “the sensory changes are not limited to the distribution of the saphenous nerve but includes the medial and anterior aspects of the knee from the superior pole of the patella to the proximal tibia” (p. 541).

Koh et al. (2017) further determine that an adductor canal block will provide “complete sensory loss of the medial, anterior, and lateral aspects of the knee extending from the superior pole of the patella to the proximal tibia, with no noticeable quadricep strength loss” (p. 89). In comparison to a femoral nerve block, since an adductor canal block is performed more distally than a femoral nerve block not all “four major divisions of the quadricep muscle are blocked, instead just the motor nerve innervating the vastus medialis muscle” (Sztain et al., 2015, p. 559). This in theory results in less quadricep weakness with an adductor canal block than seen in a femoral nerve block with similar analgesic effects. An adductor canal block for a total knee arthroplasty therefore can be considered a promising alternative to a femoral nerve block to avoid quadricep weakness (Hegazy & Sulta, 2015). Although this is true, high local anesthetic

volumes, or a block placed too proximally can induce additional quadriceps weakness by anesthetizing more motor nerves innervating the quadriceps muscle (Frag & Mounir-Soliman, 2016). For this reason, the proper understanding of the anatomy and procedure of performing an adductor canal block is paramount for successful placement.

Performing the block. To perform an adductor canal block, the middle third of the thigh is sterilely prepped. An ultrasound transducer is then placed perpendicular to the thigh (Frag & Mounir-Soliman, 2016). At this point viewing the adductor canal under ultrasound the femoral artery, saphenous nerve, vastus medialis, sartorius muscle, and adductor longus can be identified (Frag & Mounir-Soliman, 2016). A 22-gauge needle is inserted in-plane to the ultrasound transducer from a lateral to medial approach (Frag & Mounir-Soliman, 2016). The needle is advanced through the sartorius muscle towards the saphenous nerve running laterally to the femoral artery (Frag & Mounir-Soliman, 2016). At this point if negative aspiration is achieved 1-2 ml of local anesthetic is administered to confirm placement of the needle. After needle placement is confirmed the remaining amount of approximately 20 ml is injected, with periodic aspiration conducted to ensure the needle has not migrated into the surrounding vasculature (Frag & Mounir-Soliman, 2016). “The duration of a single-shot adductor canal block with bupivacaine 0.5% is not well known, but it is reasonable to less than 24 hours based on the expected duration of a bupivacaine nerve block” (Patterson et al., 2015, p. 42). Patterson et al. (2015) also “found that the effects on a single shot adductor canal block dissipated within the first 24 hours” (p. 42) after reviewing research conducted by Kim et al. (2014).

Literature Review

The randomized controlled studies, retrospective studies, systematic reviews, and meta-analyses analyzed in this literature review all shared similar characteristics in their research. All

of the studies reviewed compared both an adductor canal block to a femoral nerve block in regard to quadricep strength, ambulation, analgesia, and opioid consumption. Inclusion and exclusion criteria were also similar in terms of the researchers' determining patient participation based on age, American Society of Anesthesiologist's classification, allergies, comorbidities, medication usage, and contraindications to regional anesthesia. In addition, each study utilized some form of research blinding to prevent bias, while also including between thirty to two-hundred and ninety-seven patients in order to provide an adequate number of participants to support the researchers' findings. Finally, numerous of the studies referenced other relevant studies on this topic, allowing them to better make conclusions, and identify areas of limitations.

Throughout the multiple randomized controlled studies, retrospective studies, systematic reviews, and meta-analyses included in this review, they all utilized or referenced similar tests to determine quadricep weakness, ambulation, analgesia, and opioid consumption. For quadricep weakness for instance several studies such as Kim et al. (2014) utilized dynamometer readings to assess quadricep strength, while others such as Lim et al. (2018) referenced the "timed up and go" test to assess mobilization postoperatively. As for analgesia, both numerical rating scales and visual analog scales for assessing pain can be seen utilized either individually or in combination throughout the studies reviewed. Finally, opioid consumption was also assessed in the studies reviewed, with one study done by Lim et al. (2018) further defining what they considered as a clinically significant opioid consumption difference of ten milligrams of morphine.

Quadricep Weakness

Altogether the numerous studies, systemic reviews, and meta-analyses reviewed all shared a commonality in their findings. A randomized controlled study conducted by Jaeger et al. (2013) involving forty-eight patients compared adductor canal block versus femoral nerve block

quadricep strength in comparison to the participant's preoperative readings utilizing a dynamometer. Those results found that at twenty-four hours postoperatively those who received an adductor canal block presented with quadricep muscle strength at fifty-two percent of baseline, compared to eighteen percent of baseline for those receiving a femoral nerve block (Jaeger et al., 2013).

Tan et al. (2018), a randomized controlled study involving two-hundred participants shared similar findings as Jaeger et al. (2013), regarding adductor canal block recipients' displaying superior quadricep strength within the twenty-four-hour mark but found no quadricep muscle strength difference between the two blocks when assessed at forty-eight and seventy-two hours. In addition, another randomized study conducted by Kim et al. (2014) found significant superior quadricep muscle dynamometer readings at six and eight hours postoperatively in the adductor canal block group, but no significant difference at twenty-four hours and later in the ninety-three patients studied. Referring to the previous three studies, Lim et al. (2018), a randomized controlled study with thirty participants, did not conduct quadricep strength testing in the first twenty-four hours postoperatively, but did find no strength difference when assessed at twenty-four and forty-eight hours.

In comparing quadricep strength between the two blocks discussed, all three meta-analyses reviewed shared common findings to the previous randomized studies referenced. According to Koh et al. (2017), a meta-analysis of thirty-two articles, quadricep strength was found to be greater in the adductor canal block at hourly increments assessed at two, six, and eight hours, "however, quadricep strength on postoperative day one or two did not differ" (p. 91). Although Li & Ma (2016), a meta-analysis of nine articles involving six-hundred and thirty-nine patients also found superior quadricep strength in those that received an adductor canal

block, they determined there to be a significant difference in strength even up until forty-eight hours postoperatively. Lastly, the meta-analysis involving twelve studies conducted by Wang et al. (2017) shared similar findings to Koh et al. (2017) and Li & Ma (2016), but with findings covering a wider hourly range postoperatively. Wang et al. (2017) reported that “results showed that the adductor canal block was associated with greater quadriceps strength compared with a femoral nerve block throughout most time measurements at 4-6, 12, 24, 48, and 72 hours” (p. 3).

Ambulation

Hegazy & Sulta (2015) found that patients who received an adductor canal block were able to ambulate on both postoperative day one and two, while those who received a femoral nerve block were not all able to ambulate on the first day postoperatively. In their randomized controlled study involving one-hundred and seven participants, Hegazy & Sulta (2015) also observed that those in the adductor canal block group were able to also perform the “timed up and go” test significantly faster than those in the femoral nerve block group on the first postoperative day, while both groups displayed similar times on the second day. According to the retrospective review of two-hundred and ninety-seven patients, Ludwigson et al. (2015) found greater ambulatory ability and distance in the adductor canal block group in both postoperative day one and two, although in their study a single shot adductor canal block was compared to a continuous femoral nerve block catheter infusion.

In comparison, the Patterson et al. (2015) retrospective chart review of one-hundred and fourteen patients shared similar findings to Ludwigson et al. (2015), but only found significant ambulatory distance with improved physical therapy participation in the adductor canal block group on the first day postoperatively. Finally, a randomized controlled study conducted by Sztain et al. (2015) involving thirty patients also found a significant difference between those

who received an adductor canal block versus those with a femoral nerve block in terms of both the “timed up and go” test and ambulation. In their findings, the adductor canal block group, twenty seven percent of patients on postoperative day zero could complete both tests (Sztain et al., 2015). These results increased on postoperative day one and two, respectively to ninety-three and one-hundred percent (Sztain et al., 2015). In contrast, according to Sztain et al. (2015) those who could complete both tests in the femoral nerve block group on postoperative day zero, one, and two, were zero, fifty-three, and seventy-three percent.

In the meta-analysis conducted by Koh et al. (2017) the researchers found most studies reviewed presented evidence that patients in the adductor canal group were able to ambulate greater distances on both postoperative day one and two. Although ambulation distance was found to be greater, “timed up and go” tests were contradictory as some studies concluded there was no difference between the two blocks, with others concluding the adductor canal block group had superior results (Koh et al., 2017). In comparison, to Wang et al. (2017), another meta-analysis, the researchers found that patients who received an adductor canal block were able to perform the “timed up and go” test sooner and faster than those in the femoral nerve block group in the first twenty-four hours postoperatively. Although the adductor canal block provided superior ambulation and performance in the “timed up and go” test within the first twenty-four hours, there was found to be no significant difference between the two blocks after forty-eight hours postoperatively (Wang et al., 2017).

Analgesia

In terms of analgesia, most of the studies reviewed shared similar findings to one another, with only two coming to conflicting conclusions. The confounding theme was that patients who received an adductor canal block shared similar numerical pain and visual analog scale results as

those who received a femoral nerve block. Hegazy & Sulta (2015) found no significant difference in terms of numerical pain scores between the two blocks on both postoperative day one and two. Jaeger et al. (2013) assessed pain utilizing the visual analog scale postoperatively at two, four, eight, and twenty-four hours, with no difference between the blocks' pain scores at both rest and with flexion. Although Kim et al. (2014) used a numerical pain scale, the researchers also found similar results as Jaeger et al. (2013) in that numerical pain scale findings between the two block groups did not provide a clinically significant difference in terms of pain when assessed between six to forty-eight hours postoperatively.

In another retrospective chart review, findings also supported that an adductor canal block is non-inferior to a femoral nerve block in terms of pain. This study referenced, conducted by Patterson et al. (2015), found that there was no pain score difference between both blocks within the first twenty-four hours. In contrast to the above findings, two studies found conflicting results, showing that a femoral nerve block does provide improved analgesia postoperatively in comparison to an adductor canal block. In one of these studies the researchers discovered that in the post-anesthesia care unit those who were provided with a femoral nerve block required less opioids, suggesting higher pain scores were noted in the adductor canal block group; but after that period pain scores were similar between the two (Sztain et al., 2015).

Tan et al. (2018) provided even more conflicting results than Sztain et al. (2015). In their study they found that pain visual analog scale scores were higher in the patients who received an adductor canal block between two to twenty-four hours, primarily regarding lateral knee pain (Tan et al., 2018). Although this finding suggests inferior analgesia in the adductor canal group, Tan et al. (2018) concluded that overall visual analog scale pain scores for overall knee pain were similar between both groups.

Koh et al. (2017) concluded that “current evidence supports that an adductor canal block provides comparable analgesic efficacy” (p. 93) when compared to a femoral nerve block. The meta-analysis conducted by Li & Ma (2016) also reached a similar conclusion in that no clinically significant difference in pain scores between adductor canal and femoral nerve block patients were noted at twenty-four and forty-eight hours postoperatively whether at rest or during activity. Wang et al. (2017) further supported the previous two meta-analysis referenced, concluding after reviewing ten studies that “the adductor canal block and femoral nerve block groups were not statistically significantly different with regard to pain during rest at each time point” (p. 4) from the post-anesthesia care unit to seventy-two hours postoperatively. This conclusion was affirmed by Wang et al. (2017) after reviewing eight studies looking at pain postoperatively with activity.

Opioid Consumption

Similar to the review of the literature regarding analgesia, opioid consumption after a total knee arthroplasty was comparable between the two blocks. According to Kim et al. (2014) “the adductor canal block group had a cumulative opioid intake that was not inferior to the femoral nerve block group at six to eight hours post-anesthesia” (p.545). These findings were also found to be the same even throughout the postoperative period up to the forty-eight hours assessed (Kim et al., 2014). In support, Lim et al. (2018) also found there to be no significant morphine consumption difference between the competing peripheral nerve blocks. In addition to the findings from these two studies, six additional studies supported the previous findings through evaluation of either opioid consumption as a whole, or specific opioids such as morphine and hydromorphone. Altogether Kim et al. (2014), Tan et al. (2018), Hegazy & Sulta (2015), Jaeger et al. (2013), Lim et al. (2018), and Patterson et al. (2015) all found no clinically

significant postoperative opioid consumption difference when comparing those who received an adductor canal block to those receiving a femoral nerve block.

In contrast to the previous findings on opioid consumption, Sztain et al. (2015) did find that those who received a femoral nerve block required less supplemental opioids. Although this was found, increased supplemental opioid consumption by those in the adductor canal block was short-term, and only occurred in the post-anesthesia care unit; after that period little difference was found (Sztain et al., 2015).

In reviewing three meta-analyses, the above studies concluding little difference between the two peripheral nerve blocks in terms of opioid consumption is supported. Opioid consumption in five studies was reviewed by Li & Ma (2016), with their findings stating, “there was no significant difference at twenty-four and forty-eight hours postoperatively between the two groups” (p. 2617). Koh et al. (2017) reviewed six studies and six meta-analyses pertaining to this topic, resulting in the same conclusion as Li & Ma (2016). Lastly, in support of the previous two meta-analyses, Wang et al. (2017) after reviewing twelve randomized controlled studies also found that opioid consumption was non-inferior in those who received an adductor canal block in comparison to those receiving a femoral nerve block.

Findings

The patient described above in the case report undergoing a unilateral total knee arthroplasty received a postoperative adductor canal block. Although a femoral nerve block has been shown to provide effective pain relief after a total knee arthroplasty, an adductor canal block was chosen due to recent literature and the experience of the anesthesia professional (Wang et al., 2017). Although this peripheral nerve block was decided on, “a major concern

among practitioners is whether an adductor canal block provides enough sensory coverage for a total knee arthroplasty” (Kim et al., 2014, p. 548).

This is significant because according to Koh et al. (2017) “inadequate pain management after total knee arthroplasty impedes recovery, increases the risk of postoperative complications, and results in patient dissatisfaction” (p. 87). Throughout the postoperative period and review of the patient’s chart, pain management was deemed as adequate, evident by the prolonged time intervals and minimal medication dosages administered in the forms of acetaminophen, ketorolac, oxycodone, and tramadol. In addition, the adductor canal block provided the patient the ability to participate in physical therapy the following day along with meeting the hospital’s discharge criteria.

With the findings discussed in this literature review an adductor canal block is a viable option in place of a femoral nerve block in patients undergoing a total knee arthroplasty. The findings from the case report suggest supportive data of the numerous studies, systematic reviews, and meta-analyses reviewed. The patient had adequate pain control with minimal opioid consumption, along with the quadricep muscle strength to actively participate in physical therapy and achieve discharge on the first postoperative day. Altogether Wang et al. (2017) provides a statement fitting both this case report and the findings evident in this literature review that an “adductor canal block is an effective alternative to provide less motor strength impairment and faster recovery but provides a comparable level of pain relief with decreased risk of falls in comparison with the femoral nerve block” (p. 11).

Evidence Based Practice Recommendations

After synthesizing the research articles for adductor canal blocks in total knee arthroplasties, four recommendations have been formulated. The first recommendation is that

surgical patients undergoing a total knee arthroplasty should receive a postoperative adductor canal block over a femoral nerve block. Since both blocks have comparable analgesic effect and opioid consumption rates, the increased quadricep muscle strength and ability to ambulate on the first postoperative day is the driving factor in selecting the adductor canal block.

The second recommendation is that a protocol for a multimodal approach to addressing postoperative pain in addition to an adductor canal block should be developed and utilized in those patients undergoing total knee arthroplasty. These protocols should be in place in case of inadequate pain management provided by an adductor canal block or to address the block wearing off. For example, the patient in this case report was still supported with opioids and non-steroidal anti-inflammatory medications to both address and prevent postoperative pain with positive results. The possibility of administering an additional peripheral nerve block may also be a viable option, although this may prolong the patient's hospital length of stay and their ability to participate in physical therapy.

The third recommendation for education of relevant hospital staff caring for a patient who underwent a total knee arthroplasty should occur to prevent postoperative complications such as falls. Since the adductor canal block can potentially migrate due to large block volumes or improper block placement, nerves other than that communicating with the vastus medialis muscle may be blocked, resulting in a more profound quadricep muscle blockade and increasing a patient's risk for a fall.

The fourth recommendation is that additional large participant randomized controlled studies should be conducted to further discover the benefits of an adductor canal block in patients undergoing a total knee arthroplasty. Although there are numerous studies available on the topic, all the studies reviewed had two-hundred and ninety-seven or less participants. In

addition, studies such as Wang et al. (2017) stated one of their limitations being a lower number of patients. Since low sample sizes from a population can create inaccurate findings, large sample sizes will better represent the population, improving the quality of the study and its findings.

Conclusion

Both adductor canal blocks and femoral nerve blocks can be utilized by anesthesia professional for patients undergoing total knee arthroplasty. Ideally, a peripheral nerve block utilized postoperatively in total knee arthroplasty procedures should minimize quadriceps weakness and its effect on ambulation, while also providing adequate analgesia with minimal opioid requirements. These attributes are vital as they can affect patients' satisfaction, safety, their overall outcome, and potentially cost. For these reasons, the attributes provided by an adductor canal block are ideal. An adductor canal block for patients undergoing total knee arthroplasty is a promising alternative to a femoral nerve block.

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Appendix A

Adductor Canal Block Versus Femoral Nerve Block in Total Knee Arthroplasty

Alexander Olson, SRNA

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Introduction

Total knee arthroplasty

- Approximately 670,000 total knee arthroplasties conducted each year (Wang et al., 2017)
- Associated with:
 - Severe pain in over 50% of patients (Wang et al., 2017)
 - Quadriceps strength reduction of 60-83% (Jaeger et al., 2013)
- Currently, femoral nerve blocks have been considered a standard therapy in patients undergoing total knee arthroplasties (Koh et al., 2017)

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Case Information

- Right total knee arthroplasty
- 41 year old
- 99 kilogram (BMI: 32)
- Male
- ASA II
- Allergies to bee stings, pemoline, trimethoprim, and mupirocin

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Pre-operative Evaluation

- Past Medical History
 - Hypertension, hyperlipidemia, asthma, gastroesophageal reflux, hypothyroidism, osteoarthritis, bipolar, and schizoaffective disorder
- Surgical History
 - Hernia repair, appendectomy, cholecystectomy, shoulder arthroplasty, and knee arthroplasty
- Pre-op VS
 - BP: 140/91 HR: 101/min RR: 16/min T: 36.7C O2: 96% RA
- Pertinent labs/EKG/chest X-ray, etc.
 - Hgb: 14 g/dL Hct: 42% Plt: 225,000
- Airway evaluation
 - Mallampati class III, thyromental distance of three fingerbreadths, mouth opening greater than three fingerbreadths, full neck range of motion

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Anesthetic Course

- Pre-induction
 - 2 mg midazolam
 - 75 mcg fentanyl
 - 500 ml lactated ringer's
 - 1.8 ml bupivacaine 0.75% in 8.75% dextrose spinal
- Induction
 - 2 g cefazolin
 - 75 mcg/kg/min propofol

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Anesthetic Course Continued

- Maintenance
 - 75 mcg/kg/min propofol
 - 1 g tranexamic acid
 - 50 mcg phenylephrine
- Emergence
 - 75 mcg/kg/min propofol discontinued
- Totals
 - 1300 ml lactated ringer's
 - 200 ml estimated blood loss

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PACU Through Discharge

- PACU
 - Vital signs stable
 - No complaints of pain or nausea
 - Adductor canal block
 - 25 ml of ropivacaine 0.5%
 - No adverse effects noted
 - Patient transferred to the floor
- 24 hour postoperative period
 - Physical therapy
 - Discharge

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Peripheral Nerve Blocks

- “Peripheral nerve blocks have been used as a contemporary multimodal approach to pain control after total knee arthroplasty” (Koh et al., 2017, p. 87)
- Benefits:
 - Reduced nausea/vomiting, postoperative pain, bleeding, and hospital length of stay
 - Improved patient satisfaction

(Nageh et al., 2018)

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Lower Extremity Anatomy and Innervation

- The femoral nerve arises from the lumbar nerve roots two through four
- Divides into two branches:
 - Anterior
 - Motor innervation: pectineus and sartorius muscles
 - Sensory innervation to the anterior surface of the thigh
 - Posterior
 - Motor innervation: rectus femoris, vastus medialis, vastus intermedius, vastus lateralis, and articularis genus
 - Sensory innervation: medial/anteromedial/posteromedial aspects of the lower extremity from the distal thigh to medial malleolus

(Nageh et al., 2018) (Farag & Mounir-Soliman, 2020)

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Adductor Canal Block

- “The adductor canal is located at the middle one third of the thigh and runs from the apex of the femoral triangle proximally to the adductor hiatus distally” (Li & Ma, 2016, p. 2617).
- Located in the adductor canal are the:
 - Saphenous nerve
 - Medial femoral cutaneous nerve
 - Articular branches from the obturator nerve
 - Nerve innervating the vastus medialis

(Kim et al., 2014)

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Adductor Canal Block Continued

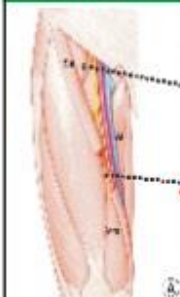
- Procedure
 - Middle third of the thigh is sterilely prepped
 - Ultrasound probe placed perpendicular to the middle third of the thigh
 - Visually the ultrasound should show the:
 - Femoral artery
 - Femoral vein
 - Saphenous nerve
 - Vastus medialis muscle
 - Sartorius muscle
 - Adductor longus muscle
 - Approximately 20 ml of local anesthetic is injected lateral to the femoral artery

(Farag & Mounir-Soliman, 2016)

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Adductor Canal Block Versus Femoral Nerve Block



- B. Femoral Nerve Block
- C. Adductor Canal Block

(Koh et al., 2017)

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Literature Review

- Adductor Canal Block Versus Femoral Nerve Block in Total Knee Arthroplasty
 - PICO question
 - In surgical patients undergoing a total knee arthroplasty does an adductor canal block provide similar postoperative analgesia/opioid consumption with improved quadricep muscle strength/ambulation in comparison to a femoral nerve block?
 - Eleven articles reviewed including:
 - Randomized controlled studies, retrospective studies, systematic reviews, and meta-analyses.

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Quadricep Strength

- Randomized controlled studies
- Jaeger et al. (2013)
 - At 24 hours postoperatively the adductor canal block showed superior dynamometer readings
 - Tan et al. (2018)
 - Superior quadricep strength within 24 hours postoperatively
 - Kim et al. (2014)
 - Superior quadricep muscle dynamometer readings postoperatively at 6-8 hours
 - Lim et al. (2018)
 - No quadricep muscle strength difference at 24-48 hours postoperatively

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Quadricep Strength Continued

- Meta-analyses
- Koh et al. (2017)
 - Greater quadricep strength at 2-8 hours postoperatively
 - Li & Ma (2016)
 - Superior quadricep strength up to 48 hours postoperatively
 - Wang et al. (2017)
 - Improved quadricep strength at most time intervals measured between 4-72 hours postoperatively

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Ambulation

- Randomized controlled studies
- Hegazy & Sulta (2015)
 - Patients able to ambulate on postoperative day 1 and 2
 - Sztain et al. (2015)
 - Greater ambulatory distance and "timed up and go" test postoperatively
- Retrospective reviews
- Ludwigson et al. (2015)
 - Greater ambulatory distance on postoperative day 1 and 2
 - Patterson et al. (2015)
 - Significant ambulatory distance/physical therapy participation on postoperative day 1

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Ambulation Continued

- Meta-analyses
- Koh et al. (2017)
 - Greater ambulatory distance on postoperative day 1 and 2
 - Contradictory results on "timed up and go" tests postoperatively
 - Wang et al. (2017)
 - Superior ambulatory distance and "timed up and go" tests in first 24 hours postoperatively

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Analgesia

- Randomized controlled studies
- Hegazy & Sulta (2015)
 - No difference in numerical pain scores postoperatively
 - Jaeger et al. (2013)
 - No difference in visual pain scores postoperatively
 - Kim et al. (2014)
 - No difference in numerical pain scores postoperatively
 - Sztain et al. (2015)
 - Potentially higher pain scores in the PACU (no difference after)
 - Tan et al. (2018)
 - Higher pain scores between 2-24 hours postoperatively

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Analgesia Continued

Meta-analyses

- Koh et al. (2017)
 - Comparable analgesic efficacy postoperatively
- Li & Ma (2016)
 - No clinically significant difference in pain scores at 24-48 hours postoperatively
- Wang et al. (2017)
 - No difference in pain scores up to 72 hours postoperatively

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Opioid Consumption

- Kim et al. (2014), Lim et al. (2018), Tan et al. (2018), Hegazy & Sulta (2015), Jaeger et al. (2013), and Patterson et al. (2015)
 - No clinically significant postoperative opioid consumption difference
- Sztain et al. (2015)
 - Increased opioid consumption in the PACU (little difference after)

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Opioid Consumption Continued

Meta-analyses

- Li & Ma (2016)
 - No significant difference at 24-48 hours postoperatively
- Koh et al. (2017)
 - No significant difference 0-48 hours postoperatively
- Wang et al. (2017)
 - Opioid consumption non-inferior

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Recommendations

- Patients undergoing a total knee arthroplasty should receive a postoperative adductor canal block over a femoral nerve block.
- A protocol for a multimodal approach to addressing postoperative pain in addition to an adductor canal block should be developed and utilized in those patients undergoing total knee arthroplasty

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Recommendations Continued

- Education of relevant hospital staff caring for a patient who underwent a total knee arthroplasty involving an adductor canal block should occur
- Additional large participant randomized controlled studies should be conducted

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Conclusion

- Case study
 - Adductor canal block was utilized postoperatively in a total knee arthroplasty procedure
- Literature supports that an adductor canal block for patients undergoing total knee arthroplasty is a promising alternative to a femoral nerve block.

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Thank You Are There Any Questions?



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