COMPARING PERIOPERATIVE PAIN CONTROL EFFICACY OF SINGLE SHOT
AND CONTINUOUS ADDUCTOR CANAL BLOCK

A Research Project

by

Cheryl Walter, MSPT, BSN, CCRN, SRNA

Presented to
Graduate Research Committee of Newman University’s
Nurse Anesthesia Program
and
Nancy Lugo-Baez, RN, DNP, Principal Investigator

In partial fulfillment of the requirements for a
Master of Science in Nurse Anesthesia

Nurse Anesthesia Program
School of Nursing and Allied Health
Newman University
Wichita, KS
Candidate’s Name: Cheryl Walter, SRNA

Title: Comparing Perioperative Pain Control Efficacy Of Single Shot And Continuous Adductor Canal Block

Status of Proposal: _ Approved

Date of Defense Meeting: July 9, 2019

This form is to be completed by the researchers and signed by each committee members.
May 10, 2019
Acknowledgements

I would like to give a heartfelt thank you to Nancy Lugo-Baez, RN, DNP, Principal Investigator and Dr. Megan Cook who without their knowledge and guidance, this project would not have been possible. Thank you also to Joe and Ben Walter, my sons, for their love, support, encouragement and faith throughout this program.
Abstract

Title: Comparing Postoperative Pain Control Efficacy of Single Shot versus Continuous Adductor Canal Blockade

Investigator: Cheryl Walter, MSPT, BSN, CCRN, SRNA

Principal Investigator: Nancy Lugo-Baez, RN, DNP

Total knee arthroplasty (TKA) is a profoundly painful procedure. Anesthesia professionals often help control pain for these patients by administering a peripheral nerve block. The femoral nerve block (FNB) had been the technique of choice; however, it was found to cause quadricep muscle weakness that delayed rehabilitation, recovery and increased the risk of falls. The adductor canal block (ACB) emerged as a peripheral nerve block treatment option that conferred pain relief without causing quadricep weakness. The femoral nerve block was found to deliver even better analgesia when given as a continuous infusion through a catheter. It was reasonable to postulate that an ACB would also give superior pain relief if it were administered as a continuous infusion instead of a one-time injection. Though both single ACB (SS-ACB) and continuous ACB (cACB) have been shown to reduce pain in patients receiving unilateral total knee arthroplasty, few studies have compared the techniques head to head. The purpose of this project was to conduct a rapid review of studies comparing the two techniques directly. Four databases were queried with specific search terms. Four randomized controlled trials directly comparing the two techniques were found. The four studies were appraised using a non-inferiority trial therapy worksheet. The findings indicate that the two techniques are equal in patient reported pain scores. Patients receiving the SS-ACB used the same or less analgesic equivalents of morphine during their hospital stay. The findings of this study indicate that the SS-ACB is non-inferior.
**Table of Contents**

Title Page 1  
Acknowledgements 2  
Abstract 3  
Table of Contents 4  
Figures and Tables 6  
List of Appendices 7  

**Chapter 1:**  
Introduction 8  
Problem Statement 9  
Background and Significance 9  
Purpose of the Study 11  
Theoretical Framework 11  
Research Question 13  
Definitions  
   Conceptual Definitions 14  
   Operational Definitions 15  
Limitations and Delimitations 15  
Threats to Validity 16  
Summary 16  

**Chapter 2:**  
Introduction 17  
Key Literature Topics 17  
Studies and Findings  
   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 18  
   The Prolonged Analgesic Efficacy of an Ultrasound-Guided Single-Shot Adductor Canal Block in Patients Undergoing Total Knee Arthroplasty 20  
   A Randomized Non-Inferiority Trial of Adductor Canal Block for Analgesia After Total Knee Arthroplasty: Single Injection Versus Catheter Technique 22  
   The Analgesic Efficacy of the Continuous Adductor Canal Block compared to Continuous Intravenous Fentanyl Infusion with a Single-Shot Adductor Canal Block in Total Knee Arthroplasty: A Randomized Controlled Trial 24  
Gaps and Omissions 26  
Summary 26  

**Chapter 3:**  
Project Design 28  
Sample, Sampling Procedure, and Data Collection 29  
   Protection of Human Rights 31  
Analysis Plan 31  
Summary 31  

**Chapter 4:**  
Introduction 33
Characteristics of the Sample 34
Results/Findings 35
Summary 35

Chapter 5:
Introduction 37
Interpretation of Findings 38
Implications 39
Recommendations 39
Summary 40

References 41
List of Figures and Tables

Figures:

Figure 1: Rogers’ Diffusion of Innovation Theory 13
Figure 2: Literature Search Results 30

Tables:

Table 1: Study Characteristics and Variables 34
<table>
<thead>
<tr>
<th>List of Appendices</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appendix A – Thesis Defense Proposal</td>
</tr>
<tr>
<td>Appendix B – Duke and McMaster Non-Inferiority Trial Worksheets</td>
</tr>
</tbody>
</table>
Chapter 1

Introduction

Total knee joint arthroplasty is a common orthopedic surgical procedure that is followed by intense rehabilitation in order to regain enough strength for safe ambulation. Pain control is an important component of the perioperative process that can facilitate early joint mobilization and safe ambulation. Without adequate pain control, the patient is subject to complications related to immobility, delayed discharge from the hospital and delayed rehabilitation. Multimodal analgesia such as non-opioid pain medications, ice, compression, elevation and a gentle range of motion provides some of the pain relief that mitigates these complications. Anesthesia providers play an important role in pain management for the total knee patient with an arsenal of regional nerve blocks. The two most common are the femoral nerve block (FNB) and adductor canal block (ACB). The FNB has fallen out of favor because of its association with motor weakness and increased fall risk. The ACB is favored for its ability to block the sensory portion of the nerves thus sparing motor nerves and decreasing complications related to weakness. There are two forms of adductor canal blocks; single shot technique and continuous. The single shot adductor canal block (SS-ACB) is associated with efficacious pain control. Recently, the continuous adductor canal blockade (cACB) has been utilized to offer protracted analgesia without a compromise in motor control. Though both techniques of adductor canal blockade have been demonstrated as efficacious and effective, there has not been a direct comparison of the two techniques to determine which technique is the most efficient.
**Problem**

Patients suffering from painful knees due to destruction of chondral surfaces of the knee compartments seek relief and ease of mobility through elective total knee arthroplasty (TKA). TKA involves removing the degenerative tissue on the articular surfaces of the femur, tibia and patella and replacing them with metal and polyethylene components. In 2018, 966,000 TKAs were performed in the United States and this number is projected to rise. Additionally, knee revisions, total knee replacements and growth in technologies such as computer-aided imaging to create custom implants will decrease recovery times and allow for earlier mobility. This in turn will promote younger, more active patients to seek knee replacement sooner. Younger, healthier patients seeking TKA may be excellent candidates for fast track surgeries which will require earlier mobility for discharge. Earlier mobility can be facilitated by the demonstrably effective adductor canal block (ACB). Knee revision, unicompartmental knee arthroplasty and computer-aided knee arthroplasty patients also benefit from regional anesthesia.

**Background and Significance**

Pain control in the TKA patient is imperative to facilitate mobility and rehabilitation for successful recovery as well as mitigating complications of immobility. Pain is most acute in the first 3 days postoperative. Multimodal analgesia reduces side effects of opioid therapies and includes lumbar epidurals, spinal anesthesia, local infiltration of the joint, patient controlled analgesia and regional nerve blockade. Anesthesia providers contribute to pain relief for these patients with a variety of effective nerve blockades. The question then lies in which type of
Peripheral nerve blockade will allow optimal pain control to promote mobility, but spare motor weakness that can lead to falls and unsatisfactory outcomes. Femoral nerve blocks alone and combined with sciatic nerve blockade had been the technique of choice. Unfortunately, the femoral block affected not only sensory, but also the motor portion of the nerve thus decreasing quadricep strength, impairing balance and increasing risk of falls. Adductor canal blockade for postoperative TKA analgesia has surpassed FNB as the technique of choice. It is associated with less quadricep weakness but provides enough pain control to be an effective part of multimodal analgesia.

Two styles of adductor canal technique are currently being utilized in the total knee arthroplasty population, the single shot (SS-ACB) and the continuous (cACB) technique. The SS-ACB technique provides both excellent analgesia to the anteromedial knee and improves rehabilitation outcomes. Typically, pain relief will last several hours depending on the volume and type of anesthetic as well as the physiology of the patient. However, one study found that moderate to severe pain with movement persisted despite the SS-ACB. This led to the theory that a continuous adductor canal blockade could provide superior pain relief and enhance rehabilitative outcomes. Early studies showed that 48 hours after surgery, patients with cACBs had low mean pain scores at rest and low mean need for opioid pain medication. Because there is an infusion into an aponeurotic space, local anesthetic can travel retrograde along the course of the saphenous nerve and block enough of the femoral nerve to cause delayed motor weakness. This could conceivably result in the undesirable motor weakness seen with the femoral nerve blockade. Several recent studies have gone on to show that cACBs provide excellent pain control and decreased opioid use without the complication of motor weakness.
Evidence comparing SS-ACB to c-ACB is limited. The researcher of this study performed a review of current literature that directly compared the two techniques. The results of this study add to the current body of literature by providing a single resource comparing both techniques. Two studies show that the continuous technique is superior in patient reported pain scores while the other two studies show no statistically significant difference. Two studies show that the single shot technique is non-inferior in terms of no statistically significant difference in opioid use between groups. When comparing opioid use, only one of the four studies reported greater opioid use in the SS-ACB group. The results of this review could assist anesthesia providers in discerning the most appropriate block technique for patients undergoing total knee arthroplasty. Knowledge gained from this study could achieve desired patient outcomes and minimize cost associated with regional nerve blockade.

Purpose

The purpose of this study will be to compare the pain relief of a continuous adductor canal blockade to single shot adductor canal blockade. Specifically, a review of current literature that compares both techniques in patients undergoing total knee arthroplasty will be undertaken. If the study shows that both techniques are equal in pain control and opioid use, then the single shot may be the preferred technique as its delivery is less expensive and, therefore, more efficient.

Theoretical Framework

Rogers’ Diffusion of Innovation Theory has been widely used in healthcare and business to describe how information is spread and why it is adopted. Research is only one arm of
creating a new clinical behavior. Rogers describes five components to adopting new information or technology: relative advantage, compatibility, complexity, trialability and observability. In nursing practice, relative advantage can speak to cost-effectiveness, patient or provider benefit. Compatibility addresses concerns about perceived barriers to implementation. Complexity describes how difficult an innovation is to understand or adopt. Trialability assumes that the innovation has been considered efficacious to a degree that it can be trialed, modified and deemed effective. Observability or visibility of an innovation sparks discussion amongst stakeholders. The perceived influence of stakeholders and personal characteristics of adopters determine the degree of innovation diffusion.\textsuperscript{16} Engagement in an activity to adopt an innovation is driven by the innovation tolerance of the individual, their attitude, knowledge and perception of evidence-based practice attributes. Among all factors, attitude of the nurse was the strongest predictor of adoption.\textsuperscript{17}

Patients undergoing total knee arthroplasty have tremendous postoperative pain. Traditionally, one element of multimodal analgesia that anesthesia providers used to control this pain was the femoral nerve block. The femoral nerve block was performed proximally in the thigh where both motor and sensory fibers are found. Unfortunately, local anesthetic delivered here caused quadricep weakness and delayed rehabilitation, recovery and increased fall risk in patients undergoing TKA. Because of this, FNBs have fallen out of favor and have been replaced by the ACB. The ACB has been shown to provide analgesia that is as effective for pain control as an FNB without causing quadricep weakness. When FNBs were more commonly used, research had shown that a continuous FNB technique provided superior pain relief to a single shot FNB. Intuitively, but without evidence, providers could assume that the same would be true
for the adductor canal block; a continuous infusion would provide better pain relief than a single injection. This extrapolation from the FNB to the ACB is potentially erroneous. There is no evidence to support that the findings of the cFNB efficacy directly translate to that of the ACB. As such, providers making this leap could be exposing patients to unnecessary cost as well as risk of infection or injury.

Anecdotally, providers seem to favor either a single shot or a continuous technique when performing ACB for TKA patients. Enough information has been integrated into practice that shows both techniques provide efficacious pain control, however, few studies have compared the continuous and single-shot techniques side by side. By performing a systematic rapid review of the literature and appraising the evidence, there is a potential to bring about clinical change. This information may show a relative advantage to one technique over the other in terms of pain control and opioid use. Because both techniques are widely understood and executed, it is not a complex innovation to integrate into practice. Primary stakeholders for adopting this practice change are anesthesia providers and those involved in the cost of health-care delivery. If one technique proves superior to the other and this information is conveyed to stakeholders, it can be integrated into clinical practice. Integration will result in collaborative reinforcement of adopting the most efficacious treatment.

Research Question
Is the single shot adductor canal nerve block non-inferior to the continuous adductor canal nerve block in providing post-operative pain relief in patients undergoing total knee arthroplasty?

**Significance**

Pain control allows for early mobility and rehabilitation. This leads to shorter lengths of stay as well as fewer immobility-related side effects. Regional anesthesia provides pain relief that has been shown to reduce the use of opioids and their side effects. Femoral nerve blocks have been the most commonly used regional anesthetic technique to reduce postoperative pain. However, studies showed unequivocally that femoral nerve blocks were associated with motor weakness, delayed rehabilitation and falls. Adductor canal blocks are now more commonly used because they provide pain relief without the complication of motor blockade. Two adductor canal techniques are cited in the literature, the single shot and the continuous technique. There is little literature to support one technique over the other. If the single shot technique is equally effective, then it may be beneficial to the patient and the hospital to use, as it would be less expensive and more financially efficient than a continuous technique. If the continuous technique is superior, then this will provide justification for the additional expense of the cACB technique.

**Conceptual and Operational Definitions**

**Conceptual definitions**

**Adductor canal**: The sartorius, vastus medialis and adductor magnus form a musculoaponeurotic tunnel as they traverse the length of thigh. The sartorius forms a roof over the top of the saphenous nerve, femoral artery and femoral vein. The borders of the triangle are the adductor magnus and vastus medialis muscles.
**Single shot adductor canal nerve block:** A regional nerve blockade for the purpose of interrupting nerve transduction along the saphenous nerve; the terminal, sensory branch of the femoral nerve. Ultrasound guidance is used to confirm placement of the needle into the canal and inject 5-20 mL of local anesthetic.\(^{20}\) Block duration is dependent on the local anesthetic used. Bupivacaine 0.5% or ropivacaine 0.5 - 0.75% in a 5-30 mL dose can provide several hours of anesthesia to the medial leg and foot.\(^{5}\)

**Continuous adductor canal nerve block:** The cACB is similar to the SS-ACB in that it is also regional nerve blockade for the purpose of interrupting nerve transduction along the saphenous nerve in the region described. Several methods have been described in the literature. After the single shot technique is performed, a catheter is inserted into the adductor canal under ultrasound visual guidance. The catheter may be used with a continuous infusion of 0.2% ropivacaine via or repeated bolus doses of local anesthetic.

**Operational definitions**

**Postoperative pain rating scale:** The numerical score of pain with 0 indicating no pain and 10 the worst pain imaginable. Alternatively, a scale of 0-100 may be used with 0 indicating no pain and 100 the worst pain imaginable.

**Equianalgesic opioid consumption:** An indirect measure of patient pain. A conversion table is employed that uses the potency of morphine as a reference allowing for comparison of potency other opioids.

**Limitations and Delimitations**

Limitations to this study exist. There are few studies that directly compare the single shot to the continuous technique. Each of these studies had a slightly different methodology in both
technique and overall peri-operative management of the patient. Location of the blockade within 
the adductor canal was not standardized between the studies as the optimal ultrasound 
anatomical indicators have not yet been defined. Only one study looked at secondary measures 
such as functional recovery to gauge success of the block technique. Examining these measures 
speaks to the component of motor weakness and its inherent complications of poor rehabilitation 
outcomes and increased fall risk.

Delimitations for this study exist. Only patients undergoing total knee arthroplasty were 
included. Only studies that directly compared pain as the primary outcome of success in 
continuous versus single shot technique were used. Patients undergoing revisions of previous 
knee arthroplasty, uni-compartmental knee arthroplasty and double knee arthroplasty were 
excluded. Secondary measures such as functional mobility, hospital length of stay and direct cost 
of each technique were not included across all studies.

**Threats to Validity**

External validity: The four studies that directly compared the anesthetic technique did 
not take place in the United States. Customary medications, techniques, staffing, practice 
patterns and cultural beliefs of pain perception may have an indirect effect on outcomes. As 
such, this sample may not be representative of patients undergoing TKA in the United States. It 
could not be assumed that these results would be the same in other joint surgeries that typically 
benefit from regional anesthesia.

Internal validity: Each study that was examined conducted the SS-ACB and cACB 
techniques differently. Different medications and concentrations were used. There was variation 
in the total knee arthroplasty technique. Some surgeons used a tourniquet, and some did not.
Anesthetic techniques also varied. Some patients received spinal or epidural anesthesia with sedation, while others underwent general anesthesia.

**Summary**

Pain control after total knee arthroplasty is important for patient satisfaction, early mobility and reduction in opioid use. Adductor canal regional nerve blocks have emerged as the pre-eminent choice for regional anesthetic pain control while avoiding motor blockade. There are two techniques commonly used, the single-shot and the continuous block. There is little literature directly comparing the two methods. It is not known if one is more effective in pain relief and opioid consumption than the other or if they are equally effective. A review of literature will be conducted to discover the best practice of adductor canal block to perform for the patient undergoing unilateral total knee arthroplasty.
CHAPTER 2

Introduction

The review of literature will discuss and analyze research comparing two techniques of adductor canal blockade (ACB) used for peri-operative pain control in unilateral total knee arthroplasty (TKA) patients. Controversy exists over the superiority of single shot versus continuous technique ACB primarily in terms of pain control and opioid consumption. Secondary outcomes related to each technique type include: opioid related side effects and rescue medications, quadricep muscle strength, functional mobility, length of hospital stay and patient satisfaction. A brief historical review of the peripheral nerve block techniques for TKA will be discussed in “Key Literature Topics.” The “Studies and Findings” section will discuss the results of the review of literature and analyze the quality of each article presented. Articles were obtained from Academic Search Premier, CINAHL Complete, Health Source: Nursing/Academic Edition and MEDLINE. The “Gaps and Omissions” section will discuss areas of methodological flaws, inconsistencies and weak areas in research methods and findings. It will speak to gaps in the research as well as issues pertinent to future study.

Key Literature Topics

The culmination of research on the use of femoral nerve block after total knee arthroplasty unequivocally demonstrates favorable analgesia, but at the expense of quadricep weakness and falls. Weakness of the quadricep muscle is due to a local anesthetic blockade of the motor portion of the femoral nerve. A more recent trend in peripheral nerve blockades for this population is the ACB. Research shows that ACB compared to FNB gives equally effective analgesia, without sequelae related to motor weakness. Historically, two types of FNB
were performed for TKA patients: the single shot and the continuous infusion. Meta-analysis comparison of the two techniques revealed that the continuous femoral block provided superior analgesia to the single shot technique.\textsuperscript{23} It could be argued that if a continuous FNB provided superior analgesia, a continuous ACB would as well but without the deleterious effect of motor blockade.

The research on ACB for TKA is relatively recent and it is accumulating quickly. There is an undeniable lag in translating research into practice.\textsuperscript{24} Given the substantial lag between completed research and practice integration, TKA patients could suffer due to care that is inconsistent with evidence-based practice. They would be subject to increased falls, pain and excess opioid use; increased opioid and immobility related side effects; prolonged lengths of hospital stays and poor rehabilitation outcomes. In order to quickly translate research into practice, a rapid review of the literature was conducted. Using the Virginia Commonwealth University Rapid Review Protocol, a matrix of results was created to compare parameters and findings of qualifying studies.\textsuperscript{25} This information will be disseminated to the local anesthesia community in order to present the culmination of relevant peripheral nerve blockade analgesia for the TKA population.

**Studies and Findings**

*Adductor canal blockade following total knee arthroplasty – continuous or single shot technique? Role in postoperative analgesia, ambulation ability and early functional recovery: A randomized double controlled trial*
A prospective randomized control trial to compare post-operative analgesia, ambulatory ability and early functional recovery in patients receiving unilateral total knee arthroplasty (TKA) was undertaken. Conventionally, a femoral nerve blockade (FNB) was performed with excellent analgesia, but there was unfortunate side effect of reduced quadricep strength which affected ambulation and recovery. Many studies have emerged that show the adductor canal block (ACB), a purely sensory block, as effective in pain control as the FNB without the complication of quadricep weakness. The ACB can be administered two ways: as a one-time injection, a single shot ACB (SSS-ACB), or as a continuous infusion (cACB). At this time, no other studies compared the two techniques head-to-head in terms of post-operative pain control, early ambulation, functional recovery, opioid consumption, treatment-related side effects or complications. From January 2014 to March 2014, 87 patients undergoing TKA with spinal anesthesia and sedation were randomized into two groups: those receiving SS-ACB and those receiving cACB. Relevant characteristics of these patients were their American Society of Anesthesia physical status classification of I-III without a history of chronic pain, renal failure or contraindications to adductor canal block. The ACBs were performed immediately after surgery in the post-anesthesia care unit. Both groups received 30 mL of 0.75% ropivacaine with the last 10 mL used to facilitate catheter placement. At 4 hours post-operatively, the SS-ACB group received an injection of 30 mL normal saline through the catheter. The cACB group had a 30 mL bolus dose of 0.25% ropivacaine every 4 hours until 08:00 the morning following surgery.

Post-operative pain scores as evaluated by a visual analog scale were collected at 4, 8, 12, and 24 hours post operatively. There was significant superiority in the cACB group over the SS-ACB group at all time intervals with a P < 0.001. Pain scores on post-operative day one and
two were also superior in the cACB group P < 0.001. There was no statistically significant
difference between groups on the timed get up and go (TUG) test, 10-meter walk test, 30-second
chair test, active straight leg raise or competency ambulating with a walker on level ground or
stairs (P > 0.05). Flexion range of motion, hospital length of stay and ambulatory distance at
discharge were not statistically different between groups (P > 0.05). The authors did not report
opioid or anti-emetic consumption. They did report that two patients in the single shot group
needed rescue analgesia and were administered 50 mg of ketorolac. Additionally, no patient in
the study suffered complications of catheter site infection, heel ulceration or prolonged nerve
palsy.\textsuperscript{26}

This study is significant because it shows a reduction in pain scores between the
continuous and single shot group. It also shows that neither single or continuous ACB cause
unfavorable decreases in strength, mobility or time to discharge. Total opioid consumption was
the third point of comparison listed in the study, however, this metric was not reported on. The
cACB was not a true continuous infusion, instead it was repeated doses through a catheter which
could affect reported pain scores.\textsuperscript{26}

\textit{The prolonged analgesic efficacy of an ultrasound-guided single-shot adductor canal block in
patients undergoing total knee arthroplasty}

A prospective randomized, placebo-controlled study examining the analgesic efficacy of
the single-shot adductor canal block (SS-ACB) to the continuous adductor canal block (cACB)
in patients undergoing total knee arthroplasty (TKA) was undertaken. Recent studies show that
both types of adductor canal block provide excellent post-operative analgesia and improve
rehabilitation. It is controversial whether a single shot technique will provide analgesia comparable to that of a continuous block. The continuous technique risks complications of infection, inadvertent removal, injury and toxicity. Moreover, it is more expensive and time-consuming to perform. Eighty-four patients over a six-week period participated in the study. Patients were an American Society of Anesthesia class I – III undergoing general anesthesia for unilateral total knee arthroplasty. They were similar in all other relevant characteristics. The patients were randomly assigned to one of three groups. All three groups received an injection preoperatively and had a catheter placed post-operatively. The first group received a single shot of 20 mL of 0.5% ropivacaine preoperatively with 20 mL normal saline boluses at 12 and 24 hours post operatively (SS-ACB). The second group received a bolus dose of 20 mL of 0.5% ropivacaine at 12 and 24 hours post-operatively (cACB). The third group received only normal saline boluses pre and post operatively (control).27

The primary endpoint in this study was pain assessment using a visual analog pain scale (VAS). Ratings were obtained at baseline, 4 hours post-operative and then on post-operative days 1, 2 and 3. Additional factors analyzed included: static VAS (at rest) and dynamic VAS (during range of motion and straight leg raise), quadricep muscle strength, rescue opioid consumption, opioid related side effects, pain mediated sleep disturbances, range of motion, time for block technique, cost of block technique, hospital length of stay and patient satisfaction. Assessments were standardized by performing them from 14:00 to 16:00 by the same reviewer on each post-operative day. Static pain scores were no different for all the groups on POD 1, 2 and 3. Dynamic VAS scores were lower at all time points for the ACB groups vs the control (P < 0.05). Pain in the control group was higher than the ACB groups at 4 hours and POD 1 and 2.
Opioid consumption rates between ACB groups were not statistically significant but were significantly lower than in the control (P < 0.05). By POD 3, there was no significant difference in opioid consumption. On POD 2 and 3, there was no significant difference in quadricep muscle strength between the three groups (P < 0.001). At 4 hours and on POD 1, the SS-ACB group had superior strength (P < 0.001). POD days 1-3 revealed similar range of motion measurements and all improved over the course of those 3 days (P < 0.0001). Mean hospital length of stay was the same between groups. The SS-ACB groups reported 92% satisfaction with their perioperative analgesia compared to 74% in the cACB group and 60% in the control group.27

This study is significant because it adds a control group to the comparison. This demonstrates that both types of blocks are efficacious for mitigating pain, reducing opioid consumption and opioid related side effects. Surprisingly, it did show that range of motion is not affected by the analgesic technique. Importantly, the SS-ACB technique was similar in opioid consumption and pain scores to the continuous technique. This supports the assertion that a single shot technique is superior because it is less expensive, less time consuming and has less risk of infection, injury or dislodgement. The primary limitation to this study is that there was not a true continuous infusion of local anesthetic; it was given in two separate bolus doses which could have significantly affected the outcome of the study given the duration of action of ropivacaine versus the time that assessments were performed.27

A randomized non-inferiority trial of adductor canal block for analgesia after total knee arthroplasty: single injection versus catheter technique
A prospective randomized controlled trial to compare analgesic efficacy of a single injection ACB (SS-ACB) with dexamethasone (Dex) to a continuous ACB (cACB) for TKA while using a SS-ACB without Dex as a control was undertaken. The problem identified in this study is to discern which technique provides the best analgesia following TKA. Both techniques have evidence of supporting pain relief. A continuous infusion would intuitively seem a better choice, however, it is subject to catheter dislodgement and a risk of infection. Data was collected from July through November of 2016 on 180 patients who underwent TKA. Relevant characteristics of these patients were an American Society of Anesthesia class I-III, scheduled for a primary unilateral TKA under sedation and spinal anesthesia. High opioid use or tolerance, unsuccessful spinals, hepatic or renal failure and chronic neuropathy patients were excluded. Subjects were randomized by computer into three groups upon their arrival to the post anesthesia care unit. (PACU). The three groups were SS-ACB (control), SS-ACB with Dex, and cACB. Each patient received their designated treatment within 30 minutes of their arrival to PACU. All participants received 20 mL of 0.5% ropivacaine as the initial injection. The SS-ACB group received no additional treatment. The SS-ACB Dex group was given an 8 mg dexamethasone intravenous infusion over 10 minutes at the time of the block. The cACB group received 20 mL of 0.5% ropivacaine followed by a continuous infusion of 0.2% ropivacaine at 5 mL/hr. for 48 hours. No Dex was given.

The researchers calculated the total equianalgesic opioid consumption amount over 24 hours from the medication administration record as the primary outcome. A standard deviation of 20 g. of IV morphine was assumed and a reduction in morphine consumption by 10 mg in 24 hours was deemed to be clinically relevant. The non-inferiority margin was calculated to be a 30
mg. oral morphine equivalent. Results showed that the cACB group used the most opioids in a 24 hour period, and the SS-ACB Dex (P <0.001) and SS-ACB (P <0.001) groups were non-inferior to the cACB group. SS-ACB Dex patients used a mean difference of -24.2 mg (CI 0.5 to -48.9 mg) of opioid compared to the SS-ACB group who used -21 mg (3.2 - -45.1) opioid compared to the cACB group. With the P value downward adjusted, superiority testing did not show significance differences in opioid consumption between the SS-ACB Dex (P = 0.016) and SS-ACB (P = 0.03) over the cACB group. Secondary outcomes were 12 and 48 hour opioid consumption, use of anti-emetics, pain score at rest, time to discharge and a quality of recovery survey. At 12 hours post-operative, the SS-ACB (P <0.001) had a mean difference of -15.1 mg (-2.1 to -28.2) of opioid and the SS-ACB Dex (P <0.001) had mean difference of -20.4 mg (-6.8 to -33.9) of opioid showing that the groups were non-inferior to the cACB group. Follow up superiority testing showed a significance in the Dex group (P = 0.002), but not by the SS-ACB group (P = 0.009) in use of opioid. At the 48 mark, both the SS-ACB Dex (P = 0.36) and SS-ACB (P = 0.44) failed to show non-inferiority as there was no significant difference between the three groups for opioid consumption. There were no differences between the groups for use of anti-emetics, pain score at rest, time to discharge and a quality of recovery survey scores. No participant suffered quadricep weakness or catheter infection.

This study is significant because it demonstrates that a single shot technique, particularly in combination with dexamethasone, provides pain relief that is non-inferior to the catheter technique over a 24-hour period. This study adds to the body of literature by contributing evidence that the SS-ACB with or without dexamethasone can provide adequate analgesia, reduce the consumption of opioids without affecting time to discharge or patient perceived
quality of recovery from surgery. This is clinically significant because a single shot technique could be a good option for fast-track surgeries as well as decreasing cost of post-operative pain management.\textsuperscript{28}

The analgesic efficacy of the continuous adductor canal block compared to continuous intravenous fentanyl infusion with a single-shot adductor canal block in total knee arthroplasty: A randomized controlled trial

A prospective randomized control trial to compare the analgesic efficacy of a continuous adductor canal block to a single shot adductor canal block with intravenous fentanyl patient-controlled analgesia (IV-PCA) in patients undergoing total knee arthroplasty was undertaken. Femoral nerve blocks (FNB) have fallen out of favor due to their detrimental effects on quadricep strength and functional mobility. FNB can be administered as a single shot or a continuous technique. Evidence continues to grow that an adductor canal block (ACB) provides satisfactory analgesia without causing motor weakness. It too can be administered as a single shot or a continuous block. It is not known if cACB is superior to SS-ACB with IV-PCA. From July 2016 through March of 2017, forty-four patients were randomly assigned to one of two groups, SS-ACB and cACB. The patients were American Society of Anesthesia class I–III receiving a unilateral total knee arthroplasty under general anesthesia. Participants did not have a history of contraindications to peripheral nerve blockade, chronic pain or neuropathy. Both groups received a 20 mL injection of 0.5% ropivacaine one hour prior to surgery. The SS group was given an IV-PCA with fentanyl set at a basal rate of 0.4mcg/kg/hr with a 15-minute lock out
and a bolus of 0.4 mcg/kg. The cACB group received a continuous infusion of 0.2% ropivacaine at a basal rate of 5 mL/hr, a lock out interval of 15 minutes and a bolus dose of 5 mL.

The researchers obtained pain scores using a numeric pain rating scale (NRS) at 30 minutes, 4 hours, 24 hours and 48 hours after surgery. There was a significant difference in pain scores (P < 0.05) at 30 minutes, 4, 24 and 48 hours post-operative. There was no statistically significant difference between groups for the need of equi-analgesic morphine rescue analgesia at all time points (P = 0.142). There was a statistically significant difference between groups in total equi-analgesic morphine doses in cACB (mean ± SD: 10.5 ± 8.7) vs SS-ACB (mean ± SD: 23.8 ± 22.9) P = 0.016. There was no significant difference between the groups in quadricep strength. Secondary outcomes of nausea, lightheadedness and dizziness were not different between groups. However, the use of rescue anti-emetics was (P = 0.046).

This study is significant because it adds to the body of literature that cACB provides superior pain relief to a SS-ACB. Equally, it shows that neither block causes quadricep weakness. Importantly, the cACB group used less opioid and rescue anti-emetic than the SS-ACB group. There are important limitations in this study. The nerve block was given one hour prior to surgery and the patient underwent a general anesthetic. It is conceivable that the duration of surgery and time to recovery from the anesthetic was long enough that the block had worn off thus decreasing its effect after the knee surgery. This could potentially make the study a comparison between minimal to no ACB and a cACB. This would significantly impact the interpretation of this study. Additionally, this study was not double blinded, a sham catheter was
not given to patients receiving a single shot block. Finally, no comparison was made with a SS-ACB without IV-PCA group.²⁹

Gaps and Omissions

Each article displayed methodologic rigor and consistency within. However, when comparing the four studies, many gaps are noted between the studies. The method of anesthesia for the TKA procedure varied between studies with some studies featuring the use of spinal anesthesia and others general anesthesia. There was a difference in time of delivery of the ACB, some were delivered pre-operatively and some post-operatively. Equally, concentration, dose and repeated dose timing were different. Lastly, there were variations in the delivery of continuous ACB; some studies reported repeat bolus dosing while others used a continuous infusion. This resulted in varied conclusions about the efficacy of pain control obtained from SS-ACB versus cACB. There are only a small number of studies comparing the two techniques. Future research would benefit from a comparison of like anesthesia and delivery of ACBs.

Summary

The review of literature discussed current research comparing SS-ACB or cACB in TKA patients to relieve post-operative pain. Academic Search Premier, CINAHL Complete, Health Source: Nursing/Academic Edition and MEDLINE were searched for comparisons between the two blocks for TKA. Four studies fit the search terms. The major findings that were discussed include: pain scale report, opioid use, opioid related side effects, quadricep weakness, functional mobility, time to discharge and cost. The review of literature speaks to the decision of which block is optimal for the TKA patient in terms of pain management, prevention of side effects and
cost of treatment. Reviewing the findings of these studies allowed for examining if the SS-ACB provides superior post-operative pain relief in the TKA patient when compared to a cACB.
CHAPTER 3

Project Design

A review of literature was conducted for the purpose of drawing a direct comparison between a single shot versus continuous adductor canal blockade technique. While evidence exists for the efficacy of each block, the variations in technique, medication, dose, delivery and testing are so highly variable that it is difficult to draw a conclusion about which technique is superior. Only studies that compare the same population undergoing the same techniques within the study can speak to non-inferiority of SS-ACB over cACB.

Instrument

The instrument chosen for this project was a rapid review (RR). This review method streamlines the systematic review (SR) to yield quicker results and hasten the process of translating research into practice. A RR is characterized by a restricted scope of questions and resources characterized the nature of the question, the end user and the researcher.\textsuperscript{31} RRs are used across a wide variety of research domains from health care to business, academia to government and beyond. Different fields of study using RRs will have unique questions to ask, thus making its standardization across fields difficult. Despite this, it has been found that conclusions from RRs do not differ substantially from SRs.\textsuperscript{30,31} However, within each field, some standardizations for conducting RRs exist. Virginia Commonwealth University has developed an RR guideline to facilitate decision making and reporting in evidence-based medicine.\textsuperscript{25} This RR program recommends appraisal worksheets developed in a collaboration between Duke University and McMasters University for evidence-based medicine. This study will use the Duke and McMasters Non-Inferiority Therapy Trial Worksheet to perform a critical appraisal of each
study reported in the review of literature. This review presents a critical appraisal of similar interventions in order to prove non-inferiority of a treatment for a specific population. It will provide a non-inferiority comparison between SS-ACB and cACB in TKA patients so that findings can be presented to and potentially integrated into the practice of anesthesia providers.

Sample and Sampling Procedures

Using the EBSCOhost research platform, four databases were queried for specific terms. These included Academic Search Premier, CINAHL Complete, Health Source: Nursing/Academic Edition and MEDLINE. Searches were limited to commentaries, review articles, reviews of literature, randomized controlled trials, systematic reviews and meta-analysis. Limiting the search to these types of articles was done to collect the most reliable evidence-based methodologies. The first search was completed on January 26, 2019 and a subsequent search repeated on March 2, 2019. No new research studies were found in the follow up search. In each search, studies that were reported in foreign languages and that did not compare SS-ACB to cACB were eliminated. The first search included the terms “adductor canal” and “total knee arthroplasty or total knee replacement” and yielded 149 results. After applying the elimination criteria, four studies remained. The second search used the terms “adductor canal block” and “total knee arthroplasty or total knee replacement” and yielded 133 results. After applying elimination criteria, three studies remained. These three were duplicates from the first search. A third search using “adductor canal” and “total knee arthroplasty or total knee replacement” and “continuous” yielded 44 articles. After applying elimination criteria, three studies remained. These three were duplicates from the first search. Two were duplicates from the second search. The fourth search included the terms “adductor canal” and “total knee arthroplasty or total knee
replacement” and “catheter.” This resulted in 21 studies, three of which were duplicates from the first search and two were duplicates of the third search. The fifth search queried “saphenous nerve block” and “total knee arthroplasty or total knee replacement” and yielded 14 results, none of which met the inclusion criteria.
Protection to Human Rights

No risk to study participants existed. Only demographics of age were used. It was not necessary to obtain permission because only completed research was used in this project. No information that could identify a person was used. Approval for this study was obtained from The Institutional Review Board of Newman University.

Analysis Plan

Data analysis was completed using the Duke and McMaster University Non-Inferiority Therapy Trial Worksheet. This is a 14-point checklist that focuses on a formulaic appraisal of randomized controlled trials that compare two similar therapies. The use of an appraisal checklist allows for the systematic evaluation of trustworthiness and relevancy of data presented in a
Study. Standardization of evaluation decreases the risk of bias and increases transparency in reporting. Additionally, information from multiple sources can be consolidated into a singular location readily demonstrating how conclusions were drawn and recommendations made. The research question, “Is the single shot adductor canal block non-inferior to the continuous adductor canal block in post-operative pain control for patients undergoing unilateral total knee arthroplasty?” was answered after completion of the literature review and application of the Non-Inferiority Trial Worksheet for each source. Results were made available in a table delineating similarities and differences in the research utilized. This table is in the appendix.

Summary

Four search engines, Academic Search Premier, CINAHL Complete, Health Source: Nursing/Academic Edition and MEDLINE were queried using stringent search criteria. Four randomized control trials were found and included in this review. Using the Duke and McMaster University Non-Inferiority Therapy Trial Worksheet, the rigor of each study was assessed. These assessments were integrated into a single source to facilitate drawing conclusions and making recommendations. These checklists and their subsequent integration into a unified table allowed the research question “Is the single shot adductor canal block non-inferior to the continuous adductor canal block in post-operative pain control for patients undergoing unilateral total knee arthroplasty?” to be answered.
CHAPTER 4

Introduction

The purpose of this research project was to gather current research using a systematic review of literature on the use of single shot versus continuous adductor canal blockade for post-operative pain control in patients receiving a unilateral total knee arthroplasty. Previous research describes each technique as efficacious for use. However, there was great variety in how and when each type of block was performed, data points collected, methodology and how each patient was cared for during their perioperative course of treatment. Side-by-side comparison of the two different techniques for non-inferiority allows for the population, treatment technique, peri-operative care and data collection to be standardized within each study. Research was conducted and reported using a rapid review of literature on randomized controlled trials examining the side by side comparison of single shot and continuous adductor canal blockades. Four studies meeting search criteria were found and appraised using a non-inferiority appraisal worksheet. Examining these studies answered the research question, “Is the single shot adductor canal block non-inferior to the continuous adductor canal block in post-operative pain control for patients undergoing unilateral total knee arthroplasty?”

Characteristics of the Sample

The previously described sampling method for this project returned four studies. Each study examined American Society of Anesthesiology (ASA) category I-III patients undergoing unilateral total knee arthroplasty receiving peri-operative adductor canal blockade. Two studies examined patients receiving general anesthesia and post-operative ACB. Two studies examined
patients receiving spinal anesthesia and preoperative ACB. In three of the four studies, 20 mL 0.5% ropivacaine was used for the single shot adductor canal blockade the other study used 20 mL of 0.75% ropivacaine. Continuous adductor canal blockade dosing was different in each of the four studies. Characteristics and variables of the studies are presented in Table 1.

<table>
<thead>
<tr>
<th>Reference &amp; Purpose</th>
<th>Subjects</th>
<th>Data</th>
<th>Variables</th>
<th>Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Author, Title, Journal</strong></td>
<td><strong>Year</strong></td>
<td><strong>Purpose</strong></td>
<td><strong>#</strong></td>
<td><strong>Subject Characteristics</strong></td>
</tr>
<tr>
<td>Shah N.S., et al. Adductor canal blockade following total knee arthroplasty – continuous or single shot technique? Role in postoperative analgesia, ambulation ability and early functional recovery: a randomized double controlled trial. J Arthroplasty.</td>
<td>2015</td>
<td>Superiority of cACB vs SS-ACB for analgesia, ambulation, early functional recovery and patient satisfaction</td>
<td>87</td>
<td>ASA I-III Unilateral TKA Spinal Anesthesia</td>
</tr>
<tr>
<td>Zhang Y, et al. The prolonged analgesic efficacy of an ultrasound-guided single-shot adductor canal block in patients undergoing total knee arthroplasty. Orthopedics.</td>
<td>2018</td>
<td>Superiority of cACB vs SS-ACB for analgesia</td>
<td>75</td>
<td>ASA I-III Unilateral TKA General anesthesia</td>
</tr>
<tr>
<td>Lee S, et al. A randomized non-inferiority trial of adductor canal block for analgesia after total knee arthroplasty: single injection versus catheter technique. J Arthroplasty.</td>
<td>2018</td>
<td>Superiority of cACB vs SS-ACB for analgesia</td>
<td>177</td>
<td>ASA I-III Unilateral TKA Spinal anesthesia</td>
</tr>
<tr>
<td>Kim MK, et al. The analgesic efficacy of the continuous adductor canal block compared to continuous intravenous fentanyl infusion with a single-shot adductor canal block in total knee arthroplasty: a randomized controlled trial. Korean J Pain. January</td>
<td>2019</td>
<td>Superiority of cACB vs SS-ACB with IV-PCA for analgesia</td>
<td>44</td>
<td>ASA I-III Unilateral TKA General anesthesia</td>
</tr>
</tbody>
</table>
Table 1: Single Shot vs. Continuous Adductor Canal Block for TKA Pain

Results and Findings

Data analysis was completed using the Duke University Non-Inferiority Therapy Worksheet. This was used to decrease risk of bias, maintain prognostic balance, guard against unwarranted conclusions of non-inferiority, elucidate the treatment effect and help determine if the results are applicable to patient care.32

*Is the single shot adductor canal block non-inferior to the continuous adductor canal block in post-operative pain control for patients undergoing unilateral total knee arthroplasty?*

Two of the four studies that were examined show that the single shot adductor canal block (SS--ACB) is inferior to the continuous adductor canal block (cACB) in post-operative pain control for the unilateral total knee arthroplasty patient. One study showing inferiority used spinal anesthesia and initiated the block post-operatively.26 Patients in the other study underwent general anesthesia and the blocks were initiated pre-operatively.29 Success of the continuous canal was based on patient report of pain.26,29

Two studies showed that the SS-ACB was non-inferior to cACB technique. Patients in one study underwent spinal anesthesia with a post-operative block.28 While patients in the other study had a pre-operative block before undergoing general anesthesia.27 Non-inferiority in both studies was based on self-reported pain scores and the amount of opioids consumed.27,28

Summary

Findings of the four studies are divided. Two studies demonstrate that cACB reduces patient report of pain compared to a SS-ACB regardless. This effect was the same regardless of pre or post-operative administration of the SS-ACB and a difference in concentration of
ropivacaine. Two studies demonstrate that SS-ACB is non-inferior to cACB in terms of 
patient-reported pain. One study showed no difference in opioid consumption. Another study 
noted a decrease in opioid use in SS-ACB groups compared to cACB. A conflicting study 
showed increased opioid use in the SS-ACB group compared to the cACB group.
CHAPTER 5

Introduction

Peripheral nerve blocks are an integral part of multi-modal analgesia to control post-operative pain in patients undergoing total knee arthroplasty (TKA). Femoral nerve blocks (FNB) were the standard of care and provided excellent analgesia. Two techniques emerged in FNB delivery, a single injection and a continuous injection. Studies demonstrated that the continuous technique provided superior pain control. Ultimately, FNB, regardless of delivery technique, has repeatedly been shown to cause quadricep weakness, impair mobility and increase risk of falls due to anesthetizing the motor portion of the femoral nerve. The adductor canal blockade (ACB) emerged as an alternative to the FNB. The adductor canal contains the terminal portion of the femoral nerve and has only sensory fibers. Studies have shown the analgesic efficacy of ACB. It stands to reason, that if a continuous FNB provided superior analgesia to a single injection then so too would a continuous ACB. Studies have described efficacious pain relief in TKA patients receiving continuous ACB (cACB) and single shot ACB (SS-ACB). However, these studies were done measuring the effect of one form of ACB or while comparing it to other types of nerve blocks such as the FNB. Few studies have directly compared cACB to SS-ACB. The purpose of this study was to examine randomized controlled trials that directly compared cACB to SS-ACB on post-operative pain in the patient undergoing (TKA). It provides an answer to the question, “Is the single shot adductor canal block non-inferior to the continuous adductor canal block in post-operative pain control for patients undergoing unilateral total knee arthroplasty?”
Interpretation of Findings

Pain management with adductor canal blockade

The results of this study were evenly divided when comparing self-reported pain scores. Two studies reported that SS-ACB was non-inferior to cACB for patient reported pain and opioid consumption.\(^{27,28}\) The other two studies reported that SS-ACB was inferior to cACB for patient reported pain.\(^{26,29}\) In the two studies showing non-inferiority of the SS-ACB technique, pain scores between groups and across all time periods were not significantly different regardless of type of anesthesia and time of block placement.\(^{27,28}\) The two studies that found cACB to be superior showed significant differences between reported pain scores across all time points.\(^{26,29}\)

The results of this study show that the SS-ACB is non-inferior to the cACB when comparing pain as evidenced by total opioid consumed during the post-operative course of hospitalization. Two of three studies reporting on opioid consumption between the two groups found that there was no significant difference between groups.\(^{27,28,29}\) Of the four studies reviewed, one did not report on total opioids consumed.\(^{26}\)

Inferences About the Important Findings

The results from this rapid review of literature indicate non-inferiority of the SS-ACB technique to the cACB technique. Though results were divided in terms of pain scores, pain score alone is not a complete indication of analgesic efficacy. The amount of opioid consumed has an impact on determination of treatment efficacy. Opioid consumption can lead to costly complications such as immobility, nausea, vomiting, constipation and falls.\(^{5,7,20}\) Thus opioid consumption is a primary determinant of analgesic efficacy.
Misconceptions about the efficacy of treatment techniques can be an impediment for providers to integrate evidence-based practices. Intuitively, the cACB would seem superior because local anesthetic is being delivered repeatedly during the most painful days after knee surgery. Equally, some providers may conclude that the SS-ACB technique would be superior because it requires less medication, equipment and personnel and has less of a risk of complications, such as infection or catheter dislodgement. Rogers’ Diffusion of Innovation Theory accounts for these misconceptions that seemingly cement a practice into place regardless of evidence. This study shows patient and provider benefit which can spark a discussion amongst stakeholders and influence adoption of this evidence-based practice into patient care.

**Implications**

The findings from this study indicate that a SS-ACB is non-inferior to a cACB. This finding benefits patients, anesthesia providers, hospital administration and payors. Using a single injection technique controls pain and reduces opioid use in patients undergoing multi-modal analgesic regimens following unilateral total knee arthroplasty. This technique requires less personnel, equipment and medication as well as reduces risk of infection. Disseminating this information to anesthesia providers decreases barriers to practices that are not supported by current evidence.

**Recommendations**

A peripheral nerve blockade is an important component of multi-modal analgesia. This study supports the use of a single injection of local anesthetic in the adductor canal for patients undergoing unilateral total knee arthroplasty. This treatment is shown to be effective in reducing pain and post-operative opioid consumption. It may be beneficial for patients who are in
fast-track surgeries or early discharge surgeries.\textsuperscript{28} It may reduce costs, risk of infection and opioid related side effects.\textsuperscript{27}

More studies comparing the two techniques in patients who undergo bilateral, revision or hemi-arthroplasty would be beneficial in generalizing the results of this study to other types of knee replacement surgery. Utilizing opioid consumption as a primary outcome is particularly beneficial to support pain management through multimodal analgesia.

**Summary**

The adductor canal nerve block is an important component of multi-modal analgesia for patients undergoing the painful total knee arthroplasty. Effective pain management minimizing the use of opioids can decrease the risk of opioid-related complications, such as nausea, vomiting and immobility. The ACB emerged as the favored block in this population because it does not cause the quadriiceps weakness, delayed rehabilitation and falls that were associated with FNB. Two types of ACB have been shown to be effective, the SS-ACB and the cACB. However, few studies directly compared the two techniques. A rapid review of literature was conducted using four databases and specific search terms. Four randomized controlled trials were returned that compared the two techniques. The Duke and McMasters Non-inferiority Trial Therapy Worksheet was used to appraise each study. The results were analyzed, and it was discovered that the SS-ACB technique was non-inferior to the cACB. This will assist anesthesia providers in delivering the most effective mode of adductor canal analgesia to patients undergoing unilateral total knee arthroplasty.
References


Appendix B – Thesis Defense Proposal
Therapy, Non-inferiority trials
Citation: Shah NS, Jain MP, 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 double controlled trial. J Arthroplasty. 2015;30:1476-1481.

<table>
<thead>
<tr>
<th>How serious is the risk of bias?</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Did intervention and control groups begin the study with a similar prognosis?</td>
<td></td>
</tr>
<tr>
<td>Were patients randomized?</td>
<td>Yes, computer generated randomization table</td>
</tr>
<tr>
<td>Was randomization concealed?</td>
<td>No. One group had a visible catheter, the other group had no catheter.</td>
</tr>
<tr>
<td>Were patients at baseline with respect to known prognostic factors?</td>
<td>Yes. Patients were ASA I-III undergoing spinal anesthesia for unilateral total knee arthroplasty. Patients with renal disease, conditions that contraindicate adductor canal blockade, arrhythmia, seizures, chronic pain unrelated to the knee requiring long acting opioids, alcohol or drug abuse, allergy to local anesthetics or difficulty understanding the visual analog pain scale were excluded. There were no significant differences in demographic data, pre-operative status or operative time between the groups. The F statistic was applied to each variable between groups and revealed no significant group differences for demographics.</td>
</tr>
<tr>
<td>Was prognostic balance maintained as the study progressed?</td>
<td></td>
</tr>
<tr>
<td>Were patients, caregivers, collectors of outcome data, adjudicators of outcome, and data analysts aware of group allocation?</td>
<td>The patients and clinical investigator collecting the data were unaware of the group identities until final data analysis.</td>
</tr>
<tr>
<td>Were groups prognostically balanced at the study’s conclusion?</td>
<td></td>
</tr>
<tr>
<td>Was follow-up complete?</td>
<td>Yes. Data was reported on the 87 patients included in the study.</td>
</tr>
<tr>
<td>Was the trial stopped early for benefit?</td>
<td>No.</td>
</tr>
<tr>
<td>Were patients analyzed in the groups to which they were randomized?</td>
<td>Yes.</td>
</tr>
<tr>
<td>Did the investigators guard against an unwarranted conclusion of non-inferiority?</td>
<td></td>
</tr>
<tr>
<td>Question</td>
<td>Answer</td>
</tr>
<tr>
<td>-------------------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Was the effect of the standard treatment preserved?</td>
<td>Yes. Each participant within their group, SS-ACB or cACB, received identical methods of application for the adductor canal blockade.</td>
</tr>
<tr>
<td>Did the investigators analyze patients according to the treatment they received, as well as to the groups to which they were assigned?</td>
<td>Yes. Patients were compared within their group, then the data was synthesized and compared between the two groups. Kolmogorov-Smirnov statistic was applied to assure calculated parameters were evenly distributed. The MANOVA was performed to assess the multiple outcomes for each patient. The ANOVA was conducted for each dependent variable with alpha level &lt;0.05. The F statistic was applied to each variable between groups and revealed no significant group differences for demographics.</td>
</tr>
</tbody>
</table>
| What are the results?                                                   | 1. VAS pain scores were significantly better at 4, 8, 12 and 24 hours on the day of surgery in the cACB group than the SS-ACB group. P<0.001 for each point in time.  
2. VAS pain scores were significantly better at rest and after mobilization on POD 1 & in the cACB group than the SS-ACB group. P<0.001 for each day.  
3. For all points in time, there were significant intergroup differences revealing a superiority of the cACB over the SS-ACB. |
| How large was the treatment effect on visual analog pain scores?        | 1. VAS pain scores were significantly better at 4, 8, 12 and 24 hours on the day of surgery in the cACB group than the SS-ACB group. P<0.001 for each point in time.  
2. VAS pain scores were significantly better at rest and after mobilization on POD 1 & in the cACB group than the SS-ACB group. P<0.001 for each day.  
3. For all points in time, there were significant intergroup differences revealing a superiority of the cACB over the SS-ACB. |
| How precise was the estimate of the treatment effect?                   | There was a 95% CI of difference when comparing each group and at each time. In other words, the variations around the mean were 95% similar when cACB was compared to SS-ACB. |
| How large was the treatment effect on early patient ambulation, functional recovery and length of hospital stay? | 1. At 24 hours post block, patients were assessed on a variety of ambulatory and functional mobility tests. There was no statistically significant differences between the groups. |
| How precise was the estimate of the treatment effect?                   | There was a 95% CI of difference when comparing each group and at each time. In other words, the variations around the mean were 95% similar when cACB was compared to SS-ACB. |
| How large was the treatment effect on total opioids consumed?           | Unknown, authors did not report.                                                                                                                                                                       |
| How precise was the estimate of the treatment effect?                   | Unknown, authors did not report.                                                                                                                                                                       |
| How can I apply the results to my patient care?                        | Yes. Anesthesia professionals often care for patients undergoing unilateral total knee arthroplasty with spinal analgesia and consider the use of peripheral nerve blockade for pain management. |
Were all patient-important outcomes considered?  
\[ \text{No.} \]  
It is important to note, that though there were statistically significant differences in pain between the two groups, that overall pain levels were less than 31 on the VAS 0-100 scale at all points in time. Two additional parameters should be measured; total opioid consumption over the length of hospital stay and VAS pain rating at discharge. Knowing these two parameters would help understand efficiency.

Are the likely advantages of the novel treatment worth the potential harms and costs?  
\[ \text{It is difficult to determine the extent of the advantage of cACB over SS-ACB because opioid consumption and discharge pain scores were not reported. Thus, it is not known if the cost of administration a cACB is equal to the cost of presumed opioid consumption in the SS-ACB group.} \]

---

**Therapy, Non-inferiority trials**


---

**How serious is the risk of bias?**

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Did intervention and control groups begin the study with a similar prognosis?</td>
<td>Yes, patients were randomly assigned to one of three groups.</td>
</tr>
<tr>
<td>Were patients randomized?</td>
<td>Yes, all patients received a SS-ACB preoperatively and an adductor canal indwelling catheter post-operatively. Patients, assessors and clinical personnel were blinded, the investigators performing the nerve block were not.</td>
</tr>
<tr>
<td>Were patients at baseline with respect to known prognostic factors?</td>
<td>Yes. Patients were ASA I-III undergoing spinal anesthesia for unilateral total knee arthroplasty. Patients with chronic opioid use, alcohol or drug abuse, hypersensitivity or allergies to any of the study medications, pre-existing neuropathy or trauma/surgical history of the operative limb, diabetes mellitus combined with peripheral neuropathy were excluded. There were no significant differences in demographic data, pre-operative status or operative time between the groups.</td>
</tr>
<tr>
<td>Was prognostic balance maintained as the study progressed?</td>
<td>Yes. Patients were ASA I-III undergoing spinal anesthesia for unilateral total knee arthroplasty. Patients with chronic opioid use, alcohol or drug abuse, hypersensitivity or allergies to any of the study medications, pre-existing neuropathy or trauma/surgical history of the operative limb, diabetes mellitus combined with peripheral neuropathy were excluded. There were no significant differences in demographic data, pre-operative status or operative time between the groups.</td>
</tr>
<tr>
<td>Question</td>
<td>Answer</td>
</tr>
<tr>
<td>-------------------------------------------------------------------------</td>
<td>----------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Were patients, caregivers, collectors of outcome data, adjudicators of outcome, and data analysts aware of group allocation?</td>
<td>The patients and clinical investigators collecting the data were unaware of the group identities until final data analysis.</td>
</tr>
<tr>
<td>Were groups prognostically balanced at the study’s conclusion?</td>
<td></td>
</tr>
<tr>
<td>Was follow-up complete?</td>
<td>Yes. Seventy-five participants received full treatment and follow up according to their randomization group.</td>
</tr>
<tr>
<td>Was the trial stopped early for benefit?</td>
<td>No.</td>
</tr>
<tr>
<td>Were patients analyzed in the groups to which they were randomized?</td>
<td>Yes. Each participant within their group, SS-ACB, cACB, or control were analyzed within their group. Data was found to be similar between the groups.</td>
</tr>
<tr>
<td>Did the investigators guard against an unwarranted conclusion of non-inferiority?</td>
<td>Yes. Each participant within their group, SS-ACB, cACB, or control received identical methods of application for the adductor canal blockade.</td>
</tr>
<tr>
<td>Did the investigators analyze patients according to the treatment they received, as well as to the groups to which they were assigned?</td>
<td>Yes. Each participant within their group, SS-ACB, cACB, or control were analyzed within their group and across the groups.</td>
</tr>
<tr>
<td>What are the results?</td>
<td></td>
</tr>
<tr>
<td>How large was the treatment effect on static VAS?</td>
<td>Small effect between ACB groups.</td>
</tr>
<tr>
<td></td>
<td>Median values of static pain measurement remained at &lt;3 on the VAS.</td>
</tr>
<tr>
<td></td>
<td>Incidences of severe pain were greater in the control group than the 2 ACB groups, and no difference was observed between the 2 ACB groups.</td>
</tr>
<tr>
<td></td>
<td>On POD3, there were no significant differences between groups.</td>
</tr>
<tr>
<td></td>
<td>Maximum average pain level reported was 4/10 at 4 hours post-operative in the SS-ACB group</td>
</tr>
<tr>
<td>How precise was the estimate of the treatment effect on static VAS?</td>
<td>P values ranged from &lt;0.05 to &lt;0.0001.</td>
</tr>
<tr>
<td>Question</td>
<td>Answer</td>
</tr>
<tr>
<td>------------------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>How large was the treatment effect on dynamic VAS?</td>
<td>Small effect between ACB groups. Median values of dynamic pain measurement were similar between the ACB groups and less than the sham treatment group 4 hours post-operatively and on POD 1, 2 and 3. Incidences of severe dynamic pain were greater in the control group than the 2 ACB groups, no significant difference was observed between the 2 ACB groups. On POD3, there were no significant differences between groups. Maximum average pain value between ACB groups was a 6/10 immediately post-operative in the SS-ACB group.</td>
</tr>
<tr>
<td>How precise was the estimate of the treatment effect on dynamic VAS?</td>
<td>P values ranged from &lt;0.05 to &lt;0.0001.</td>
</tr>
<tr>
<td>How large was the treatment effect on opioid consumption?</td>
<td>No significant difference between ACB groups. No significant difference between the ACB groups on POD 0,1 and 2, but they were lower than the control. On POD 3 there were no differences in opioid consumption between groups.</td>
</tr>
<tr>
<td>How precise was the estimate of the treatment effect on opioid consumption?</td>
<td>P values ranged from &lt;0.05 to &lt;0.0001.</td>
</tr>
<tr>
<td>How large was the treatment effect on quadricep (MMT)?</td>
<td>No significant difference between ACB groups There were no differences in strength between the ACB groups at 4 hours postoperatively or on POD2 or POD3. On POD1, SS-ACB group had statistically significant greater quadricep strength than the cACB group.</td>
</tr>
<tr>
<td>How precise was the estimate of the treatment effect on quadricep MMT?</td>
<td>P values ranged from &lt;0.05 to &lt;0.0001.</td>
</tr>
<tr>
<td>How large was the treatment effect on ROM?</td>
<td>No difference No significant difference in ROM was noted between the 3 groups at any point in time.</td>
</tr>
<tr>
<td>How precise was the estimate of the treatment effect on ROM?</td>
<td>P values ranged from &lt;0.05 to &lt;0.0001.</td>
</tr>
<tr>
<td>How can I apply the results to my patient care?</td>
<td>Yes. Anesthesia professionals often care for patients undergoing unilateral total knee arthroplasty with general anesthesia and...</td>
</tr>
<tr>
<td>Were the study patients similar to my patient?</td>
<td>Yes. Anesthesia professionals often care for patients undergoing unilateral total knee arthroplasty with general anesthesia and...</td>
</tr>
</tbody>
</table>
consider the use of peripheral nerve blockade for pain management.

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Were all patient-important outcomes considered?</td>
<td>Yes. Static and dynamic pain measures, opioid consumption, strength and range of motion were analyzed.</td>
</tr>
<tr>
<td>Are the likely advantages of the novel treatment worth the potential harms and costs?</td>
<td>The SS-ACB provides sufficient analgesia and does not impact strength or range of motion when compared to cACB. The authors conclude SS-ACB is superior because it provides similar effect without the added expense or risk of infection, injury or catheter dislodgement.</td>
</tr>
</tbody>
</table>

SS-ACB: single shot adductor canal block. cACB: continuous adductor canal block. VAS: visual analog pain scale 0=no pain 10=worst pain imaginable. POD: post-operative day. MMT: manual muscle test 0= no contraction 1= flicker contraction 2=able to move gravity assisted 3=able to move against gravity 4=able to sustain mild resistance 5=able to sustain strong resistance. ROM: range of motion.

**Therapy, Non-inferiority trials**


<table>
<thead>
<tr>
<th>How serious is the risk of bias?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Did intervention and control groups begin the study with a similar prognosis?</td>
</tr>
<tr>
<td>Were patients randomized?</td>
</tr>
<tr>
<td>Was randomization concealed?</td>
</tr>
<tr>
<td>Were patients at baseline with respect to known prognostic factors?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Was prognostic balance maintained as the study progressed?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Were patients, caregivers, collectors of outcome data, adjudicators of outcome, and data analysts aware of group allocation?</td>
</tr>
<tr>
<td>Were groups prognostically balanced at the study’s conclusion?</td>
</tr>
<tr>
<td>Question</td>
</tr>
<tr>
<td>-------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Was follow-up complete?</td>
</tr>
<tr>
<td>Was the trial stopped early for benefit?</td>
</tr>
<tr>
<td>Were patients analyzed in the groups to which they were randomized?</td>
</tr>
<tr>
<td>Did the investigators guard against an unwarranted conclusion of non-inferiority?</td>
</tr>
<tr>
<td>Did the investigators analyze patients according to the treatment they received, as well as to the groups to which they were assigned?</td>
</tr>
<tr>
<td>What are the results?</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>How precise was the estimate of the treatment effect on opioid consumption?</td>
</tr>
<tr>
<td>How can I apply the results to my patient care?</td>
</tr>
<tr>
<td>Were the study patients similar to my patient?</td>
</tr>
<tr>
<td>Were all patient-important outcomes considered?</td>
</tr>
</tbody>
</table>

Citation: Kim MK, Moon HY, Ryu CG, Kang H, Lee HJ, Shin HY. The analgesic efficacy of the continuous adductor canal block compared to continuous intravenous fentanyl infusion with a single-shot adductor canal block in total knee arthroplasty: a randomized controlled trial. *Korean J Pain*. January 2019;32(1)30-38.

### How serious is the risk of bias?

<table>
<thead>
<tr>
<th>Did intervention and control groups begin the study with a similar prognosis?</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Were patients randomized?</strong></td>
</tr>
<tr>
<td><strong>Was randomization concealed?</strong></td>
</tr>
<tr>
<td><strong>Were patients at baseline with respect to known prognostic factors?</strong></td>
</tr>
</tbody>
</table>

### Was prognostic balance maintained as the study progressed?

| **Were patients, caregivers, collectors of outcome data, adjudicators of outcome, and data analysts aware of group allocation?** | No. Patients, caregivers, the data collector was not blinded. The data analyst was blinded |

### Were groups prognostically balanced at the study’s conclusion?

| **Was follow-up complete?** | Yes. All patients meeting inclusion criteria received the full program of care and were assessed according to the outlined study parameters. |
| **Was the trial stopped early for benefit?** | No. |
| **Were patients analyzed in the groups to which they were randomized?** | Yes, 44 patients in total were analyzed. |

### Did the investigators guard against an unwarranted conclusion of non-inferiority?
<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Was the effect of the standard treatment preserved?</td>
<td>Yes. Each participant within their group, SS-ACB-IVPCA or cACB, received identical methods of application for the adductor canal blockade.</td>
</tr>
<tr>
<td>Did the investigators analyze patients according to the treatment they received, as well as to the groups to which they were assigned?</td>
<td>Yes. Patients were compared within their group. Demographic and perioperative data synthesized and compared between the two groups and shown to be similar. MANOVA was used for the primary outcome of NRS scores and a P values &lt;0.05 were considered statistically significant.</td>
</tr>
<tr>
<td><strong>What are the results?</strong></td>
<td></td>
</tr>
<tr>
<td>How large was the treatment effect on NRS pain scores?</td>
<td>Significantly different.</td>
</tr>
<tr>
<td>How large was the treatment effect on opioid consumption?</td>
<td>Significantly different.</td>
</tr>
<tr>
<td>How precise was the estimate of the treatment effect on NRS pain scores?</td>
<td>P&lt;0.05</td>
</tr>
<tr>
<td>How precise was the estimate of the treatment effect on opioid consumption?</td>
<td>SS-ACB used an average of 23.8 ± 22.9 mg compared to cACB of 10.8 ± 8.7mg of morphine equivalent opioid.</td>
</tr>
<tr>
<td>How large was the treatment effect on quadriceps muscle strength?</td>
<td>No statistically significant difference.</td>
</tr>
<tr>
<td>How precise was the estimate of the treatment effect on quadriceps muscle strength?</td>
<td>N/A</td>
</tr>
<tr>
<td><strong>How can I apply the results to my patient care?</strong></td>
<td></td>
</tr>
<tr>
<td>Were the study patients similar to my patient?</td>
<td>Yes. Anesthesia professionals often care for patients undergoing unilateral total knee arthroplasty with general anesthesia and consider the use of peripheral nerve blockade for pain management.</td>
</tr>
<tr>
<td>Were all patient-important outcomes considered?</td>
<td>Yes. Opioid consumption throughout the first day post-operative is an important consideration as it is associated with the most costly and troublesome complications. Other outcomes were assessed as secondary measures.</td>
</tr>
<tr>
<td>Are the likely advantages of the novel treatment worth the potential harms and costs?</td>
<td>This study concludes that there are significant differences between groups in pain ratings and opioid use.</td>
</tr>
</tbody>
</table>
These authors conclude that the cACB is superior in pain relief to the SS-ACB with no difference in muscle strength.

IV-PCA: Intravenous Patient Controlled Analgesia. cACB: continuous Adductor Canal Block.
NRS: Numeric Pain Rating Scale 0=no pain, 10= worst pain imaginable.
I, Megan Cook, DNAP,CRNA, hereby consent to serve on the following research committee, along with student researcher, Cheryl Walter, SRNA and Principal Researcher Dr. Nancy Lugo-Baez, for her research project entitled Comparing Perioperative Pain Control Efficacy of Single Shot and Continuous Adductor Canal Block.

I understand that this responsibility includes meeting with the student and her committee periodically from now until her thesis is complete by Graduation in August 2019, to help guide her in her research, and production of the Handbook.

Furthermore, I understand that I will be expected to offer expert clinical advice with editorial critique of her study, at appropriate times as her study progresses until its completion, and will return edits in a timely manner upon request.

I also agree to attend, if possible, the defense of her thesis. Dr. Nancy Lugo-Baez if the Principal Investigator. Please contact her at 316-942-4291 ext. 2266, for any questions or concerns.

Megan Cook, DNAP,CRNA  
10/17/2019

(Name and Credentials of Committee Member)  
(Date)
I, Nancy Lugo-Baez, RN, DNP, hereby consent to serve on the following research committee, along with student researcher, Cheryl Walter, SRNA and Principal Researcher Dr. Nancy Lugo-Baez, for her research project entitled Comparing Perioperative Pain Control Efficacy of Single Shot and Continuous Adductor Canal Block.

I understand that this responsibility includes meeting with the student and her committee periodically from now until her thesis is complete by Graduation in August 2019, to help guide her in her research, and production of the Handbook.

Furthermore, I understand that I will be expected to offer expert clinical advice with editorial critique of her study, at appropriate times as her study progresses until its completion, and will return edits in a timely manner upon request.

I also agree to attend, if possible, the defense of her thesis. Dr. Nancy Lugo-Baez if the Principal Investigator. Please contact her at 316-942-4291 ext. 2266, for any questions or concerns.

(Name and Credentials of Committee Member)  1/2019

(Date)