Peri-Operative Regional Nerve Blocks (PNB) in the Treatment of Pain in Patients Undergoing Operative Fixation of Lower Extremity Fractures

Joshua K. Radi

Western Michigan University, joshradi@gmail.com

Follow this and additional works at: http://scholarworks.wmich.edu/dissertations

Part of the Anesthesia and Analgesia Commons

Recommended Citation
http://scholarworks.wmich.edu/dissertations/3188
PERI-OPERATIVE REGIONAL NERVE BLOCKS (PNB) IN THE TREATMENT OF PAIN IN PATIENTS UNDERGOING OPERATIVE FIXATION OF LOWER EXTREMITY FRACTURES

by

Joshua K. Radi

A dissertation submitted to the Graduate College in partial fulfillment of the requirements for the degree of Doctor of Philosophy Interdisciplinary Health Sciences Western Michigan University December 2017

Doctoral Committee:

Amy B. Curtis, Ph.D., Chair
Eric Vangsnes, Ph.D.
Hobie Summers, M.D.
PERI-OPERATIVE REGIONAL NERVE BLOCKS (PNB) IN THE TREATMENT OF PAIN IN PATIENTS UNDERGOING OPERATIVE FIXATION OF LOWER EXTREMITY FRACTURES

Joshua K. Radi, Ph.D.
Western Michigan University, 2017

This research explores current approaches to managing pain control in patients undergoing operative fixation of lower extremity fractures. As opioid use in the U.S. and abroad increases, alternative methods of treating and preventing opioid requirements are being examined. Patients with lower extremity fractures are susceptible to nonunion when anti-inflammatories are consumed, so alternative approaches are warranted. One such alternative, a peri-operative regional nerve block (PNB), is accomplished by injecting local anesthetic adjacent to one or more peripheral nerves supplying the area of the fracture to decrease pain (Fowler, Symons, Sabato, & Myles, 2008). The goal of this research was to determine effectiveness of PNB on decreasing the amount of opioids following surgery, during the hospital admission, and long-term for those undergoing lower extremity surgery as well as on hospital length of stay and readmission. Demographic and anthropometric data were also assessed. This work was conducted to potentially identify additional options to decrease and anticipate post-surgical pain requirements in order to reduce opioid use in the short term and, potentially, opioid addiction in the long term.

This study of those undergoing tibial plateau fracture repair at one level 1 trauma hospital in the Midwest between 2006-2015 revealed statistically significant lower post-
operative day zero opioid requirements and shorter hospital admissions in patients who received single shot PNB compared to those with no PNB for tibial plateau fracture repair. However, it was noted that elevations in opioid requirements on post-operative day one should be controlled for when utilizing PNB. A follow-up study of the same sample identified that those of White race and those who smoke had an increased risk of still being prescribed opioids long term (3 months and 6 months for White patients compared to Black patients, and at 6 months for smokers compared to non-smokers). When all lower extremity fractures were examined over the last 10 years (2006-2015), PNB rate of use continued to increase, with the largest increase associated with implementation of a dedicated PNB team. Hospital length of stay was also significantly shorter among those receiving PNB compared to those with no PNB.

PNB should be considered as a tool for decreasing post-operative opioid requirements in patients undergoing operative repair of tibial plateau fractures. PNB should also be considered for decreasing hospital length of stay in those undergoing operative fixation of all lower extremity fractures and tibial plateau fractures, specifically. Hospitals should evaluate prescribing practices with regard to long-term opioid prescriptions and create protocols to ensure the objective management of pain in all race/ethnicities, and be aware of the increased risk for long-term use among smokers and White patients. Lastly, dedicated PNB teams should be considered at institutions that perform orthopaedic trauma surgery in order to increase the use of PNB.
ACKNOWLEDGMENTS

I would like to acknowledge and thank the following individuals for their assistance and input on this research and dissertation. My advisor and committee chair, Dr. Amy Curtis, guided me throughout this process, never let quality suffer, and always held me to the highest standard. Dr. Eric Vangsnes demonstrated how an Army PA can break barriers and excel in academia, and provided me the opportunity to follow in his footsteps. My committee member, Dr. Hobie Summers, the best orthopaedic surgeon I’ve ever worked with, is a role model and lifelong mentor, who showed me that a commitment to excellence and perfection can co-exist with a warm bedside manner and positive attitude. Dr. Kieran Fogarty supported my existence in this program and demonstrated a continuous commitment to my education throughout my military commitments. Dr. Scott Byram offered clear-cut recommendations and poignant thought-provoking questions throughout the entire process. Frank DiSilvio, Jr. spent countless hours looking through Excel spreadsheets, de-identifying data, and making valuable contributions to all papers.

Most importantly, I would like to thank my wife Anna, who has been with me from the beginning moments of my decision to pursue this Ph.D. Anna spent countless nights watching me stare at my laptop and research papers scattered throughout the living room and waited patiently, deployment after deployment. I would not be here without your support, thank you.

Joshua K. Radi
# TABLE OF CONTENTS

ACKNOWLEDGMENTS ........................................................................................................ ii

LIST OF TABLES .................................................................................................................. v

LIST OF FIGURES ............................................................................................................... vi

CHAPTER

1 INTRODUCTION ................................................................................................................. 1
   Background ....................................................................................................................... 1
   References ....................................................................................................................... 9

2 UTILITY OF PERI-OPERATIVE REGIONAL NERVE BLOCK (PNB) IN TIBIAL PLATEAU 
   FRACTURES: AN ASSESSMENT OF POST-OPERATIVE PAIN AND OTHER 
   PATIENT FACTORS ......................................................................................................... 14
   Background ..................................................................................................................... 14
   Method ............................................................................................................................. 18
   Results ............................................................................................................................. 20
   Discussion ....................................................................................................................... 25
   References ....................................................................................................................... 30

3 AN ASSESSMENT OF LONG-TERM OPIOID USE FOLLOWING TIBIAL PLATEAU 
   FRACTURE REPAIR: AN AT-RISK PATIENT POPULATION BASED ON 
   RACE/ETHNICITY ........................................................................................................... 35
   Background ..................................................................................................................... 35
   Method ............................................................................................................................. 39
   Results ............................................................................................................................. 42
Table of Contents—Continued

CHAPTER

Discussion ........................................................................................................................................ 46
References ......................................................................................................................................... 50

4 PNB (PERI-OPERATIVE REGIONAL NERVE BLOCK) USE AND DEDICATED BLOCK
TEAMS ASSOCIATION WITH HOSPITAL LENGTH OF STAY AND OTHER
FACTORS FOR PATIENTS UNDERGOING OPERATIVE FIXATION OF
LOWER EXTREMITY FRACTURES ................................................................................................. 53
  Background .................................................................................................................................. 53
  Method .......................................................................................................................................... 57
  Results .......................................................................................................................................... 59
  Discussion ...................................................................................................................................... 64
  References ..................................................................................................................................... 68

5 CONCLUSION .............................................................................................................................. 72
  References ..................................................................................................................................... 77

APPENDICES

A. Western Michigan University Human Subjects Institutional Review Board Approval .... 80
B. Loyola University Institutional Review Board Approval .......................................................... 83
LIST OF TABLES

2.1 Summary of Studies That Examined Peri-Operative Regional Nerve Block (PNB) Use for Lower Extremity Fractures ................................................................. 17

2.2 Participants by Study Exclusion Criteria ................................................................. 21

2.3 Post-Operative Outcomes by PNB Status Following Tibial Plateau Fracture Repair .......... 22

2.4 Demographic and Anthropometric Characteristics by PNB Status Following Tibial Plateau Fracture Repair ................................................................. 24

2.5 Demographic Characteristics by Long-Term Opioid Use Status Following Tibial Plateau Fracture Repair ................................................................. 25

3.1 List of Number of Participants Excluded by Study Criteria ........................................ 41

3.2 Association of Race/Ethnicity With Demographics and Anthropometric Data in Patients Undergoing Tibial Plateau Fracture Repair ........................................ 43

3.3 Association of Selected Characteristics and Opioid Use at 3 and 6 months Following Tibial Plateau Fracture Repair ............................................................. 44

3.4 Logistic Regression Examining the Association Between Selected Characteristics on Opioid Use 6 Months After Tibial Plateau Fracture Repair .......................... 45

4.1 PNB Status as Determined by Dedicated Block Team Status ..................................... 61

4.2 Differences in PNB Status Among Demographics and Other Factors in Patients Undergoing Lower Extremity Fracture Repair ............................................. 63

4.3 Linear Regression Examining the Association Between PNB Status and Other Factors on Hospital Length of Stay ................................................................. 64
LIST OF FIGURES

2.1. PNB status by percent prescribed opioids 0-3 days post-operatively (POD 0: 
\( p = .044; \ t = 2.028; \) mean difference = 27.109; 95% CI (.766, 53.452); \( df = 1 \) 
between PNB and no PNB groups. ................................................................................. 21

4.1. Annual rate of PNB (peri-operative regional nerve block) use following lower 
extremity fracture repair. ................................................................................................. 60

4.2. Average hospital length of stay following lower extremity fracture repair according 
to PNB (peri-operative regional nerve block) status, \( t = 14.364, \ p < .001, \) mean 
difference = 6.5, 95% CI (5.621, 7.398)........................................................................... 61
CHAPTER 1
INTRODUCTION

Background

In the United States, pain management and opioid addiction have been on the rise over the last decade (Centers for Disease Control and Prevention [CDC], 2015). At times, the use of prescription opioids for pain control has led to addiction behavior and the eventual use of non-prescription opioids (UN Office on Drugs and Crime [UNODC], 2011). Subsequent to this epidemic of opioid use and abuse, new legislation has been written to address opioid addiction treatment programs and substance abuse prevention, including the new Comprehensive Addiction and Recovery Act (CARA) of 2016 (CARA-2016, 2016), which passed during Senate session 524 (S. 524, 2016). As a result of this legislation and increased funding, there is renewed focus and research in the area of opioid addiction, particularly in the area of treatment, but also in prevention (Calás, Wilkin & Oliphant, 2016; Harris, 2016; Knopf, 2016, 2017). This epidemic is significant because there are more than 15,000 deaths from prescription opioids annually (CDC, 2015; Rudd, Seth, David, & Scholl, 2016). Opioid death rates increased by 15.6% from 2014 to 2015, and among the 47,055 drug overdose deaths that occurred in 2014 in the United States, 60.9% of those involved an opioid (Rudd et al., 2016). Given the prevalence and severity of this issue, research is needed to determine the best methods to decrease opioid-related morbidity and mortality, including opioid-related pain management after surgery.
Tibial plateau fractures, for which opioids are commonly prescribed post-operatively, were found to have an incidence of 10.3 per 100,000 annually, with the highest frequency of these fractures occurring between the ages of 40 and 60 years of age (Elsoe et al., 2015). These fractures equate to approximately 1% of all fractures annually (Court-Brown & Caesar, 2006).

Patients with operative and non-operative tibial plateau fractures use opioid medications for pain and, at the study institution, are routinely instructed to avoid non-steroidal anti-inflammatory drugs (NSAIDs) in the fracture-healing period (H. Summers, personal communication, January 1, 2015). Nonunion (failure of a fracture to heal) has been found in humeral shaft, femoral shaft, and tibial shaft fractures as a result of NSAID use (Bhandari et al., 2003; Bhattacharyya, Levin, Vraham, & Solomon, 2005; Giannoudis et al., 2000). A study in 2014 concluded that patients with long bone fractures who received NSAIDs in the post-operative period were twice as likely as non-NSAID patients, and smokers more than three times as likely as non-smokers, to suffer complications such as nonunion/malunion or infection (Jeffcoach et al., 2014). NSAIDs were also found to inhibit Cyclo-oxygenase 2 function and angiogenesis, which are both crucial components in the bone healing process (Murnaghan, Li, & Marsh, 2006; Simon et al., 2002). Therefore drugs like Ibuprofen (Motrin, Advil), Ketorolac (Toradol), Naprosyn (Aleve), Celebrex, and others have limited practical application for post-operative pain control in fracture patients; however, researchers have conducted systematic reviews but have been unable to come to a consensus regarding the safety of NSAIDs and impact on healing following orthopaedic procedures (Marquez-Lara, Hutchinson, Nuñez, Smith, & Miller, 2016). Failure to heal a fracture results in higher rates of infection, chronic pain, hardware failure, and re-operation (Bhandari, Guyatt, Swiontkowski, & Schemitsch, 2001; Fong
et al., 2013). With such limitations regarding the treatment of pain for patients undergoing tibial plateau fracture repair, this patient population is in need of an alternative approach to controlling pain, save additional opioids.

As medical providers and legislators continue to try new techniques to combat this issue, certain fields such as orthopaedic surgery/anesthesiology are increasingly using procedures known as peri-operative regional nerve blocks (PNBs) (Cozowicz, Poeran, Zubizarreta, Mazumdar, & Memtsoudis, 2016). In a study that examined over 959,000 patients, Cozowicz et al. (2016) found that between 2006/2007 and 2012/2013, the rate of PNB use doubled in patients undergoing total knee arthroplasty or total joint replacement. These procedures aim to decrease total opioid use and alleviate pain in patients undergoing significant orthopaedic operative intervention (Nicholls, 2007). Research has been performed in various PNB techniques and researchers have evaluated effectiveness in those undergoing orthopaedic surgeries, specifically those undergoing total knee arthroplasty. Results suggest success in the application of PNB use for decreasing post-operative pain and opioid requirements (Fleischut et al., 2015; Lee, Tey, & Chua, 2012; MacFarlane, Arun Prasad, Chan, & Brull, 2009; McMeniman et al., 2010; Memtsoudis et al., 2016; Shum et al., 2009). Several recent studies have examined PNB use in lower extremity fractures (including femur, talus/calcaneus, ankle and tibial fractures) (Christensen, Møller, Nielsen, Klausen, & Sort; 2015; Diakomi, Papaioannou, Mela, Kouskouni, & Makris, 2014; Ding, Manoli, Galos, Jain, & Tejwani, 2015; Elkassabany et al., 2015; Luiten et al., 2014). The majority of these studies have shown positive outcomes and improvements in total pain control (Lee et al., 2012; MacFarlane et al., 2009; Shum et al., 2009). One study compared different PNB types (femoral vs. fascia iliaca)
without using a no-block control group and found no significant differences among pain scores between these groups, making the need to account for the specific block type less important when quantifying pain control measures (McMeniman et al., 2010). It would seem based on these findings that utilizing PNB for other types of orthopaedic injuries requiring surgery could be a viable option. In particular, as described above, the tibial plateau fracture is one such injury that frequently results in multiple days in the hospital, on average 2 to 7 days (Kayali, Öztürk, Altay, Reisoglu, & Agus, 2008; Rossi, Bonasia, Blonna, Assom, & Castoldi, 2008; Siegler et al., 2011). To better understand if there are techniques for reducing this patient population’s pain level and reliance on opioids, and also to establish relevancy in this procedure for tibial plateau fracture patients, further exploration of available research was conducted.

To my knowledge, no data have been published on the use of PNB in tibial plateau fractures. Beginning April of 2015, the following search terms were used for literature review: fracture AND regional anesthesia, tibial fracture AND regional anesthesia, tibial fracture AND peripheral anesthesia, tibial fracture AND nerve block, plateau fracture AND pain, using Scopus, Web of Science (includes Medline and the Cochrane database) and I identified no studies on this topic using those terms and databases. This search included all literature time periods but focused primarily on the last 10 years of current literature. Therefore, despite the increasing rates at which PNBs are being used in the treatment of post-operative pain in patients’ undergoing elective orthopaedic joint replacement surgery (Kurtz, Ong, Lau, Mowat, & Halpern, 2007), it appears that no study has examined the use of PNB use in patients with tibial plateau fractures requiring operative fixation.
Despite the limited evidence of the use of PNB for fractures around the knee, other research is available regarding the application of PNB for total knee arthroplasty. Regional nerve pathways in tibial plateau fracture repair and elective total knee arthroplasty are similar in that incisions in and around the knee cause pain controlled by specific nerve pathways; thus, assessing the use of PNB in knee arthroplasty patients could be applicable to this research. A study of 1,416 elective arthroplasty patients demonstrated post-operative pain control in 96.3% of patients with continuous PNB compared to no PNB, but the PNB group saw a subsequent average increase in pain medication requirements on post-operative day one following the cessation of PNB medication effectiveness, a concept referred to as rebound pain (Capdevila et al., 2005).

As the U.S. population continues to age, so too does the number of patients with arthritis who seek surgical options for their pain. To illustrate the increasing number of elective joint replacement (arthroplasty) surgeries, one study estimated that from 2005 to 2030, the demand for primary total hip arthroplasties would grow by 174% to 572,000, and the demand for primary total knee arthroplasties was projected to grow by 673% to 3.48 million procedures (Kurtz et al., 2007). These increasing projected rates point to the possibility that, over time, opioid use in the orthopaedic surgery community may continue to rise, and although we cannot predict the relative association with tibial plateau fracture rates in the future, understanding the global burden on the orthopaedic community and potential for additional opioid requirements adds value to the use of alternative modes of pain control such as PNB.

The use of PNB is not without risks, however. The risk-benefit ratio should be weighed with any procedure that we as medical professionals perform, and the PNB is no exception.
Because of this, the potential risks and complications should at least be described here to avoid subjective bias toward using PNB. The practicality and safety of PNB use for tibial plateau fractures is explored further. Tibial fractures have a known increased risk for compartment syndrome due to swelling into the compartments of the lower leg (McQueen & Gaston, 2000). Although PNB does not increase the risk for compartment syndrome, there are case reports of decreased recognition of compartment syndromes in fracture patients following fracture (Cometa, Esch, & Boezaart, 2011; Mar, Barrington, & McGuirk, 2009). Peripheral nerve injury was examined in a single-institution data review involving 1,830 patients with over 2,600 PNBs administered. The study identified only two patients who developed a definite peripheral nerve injury, or 0.11% (Williams, Ibinson, Gould, & Mangione, 2016). Overall, surgical site infection rates were a rare outcome in those undergoing total joint arthroplasty, and the use of PNB for post-operative analgesia was not found to influence the incidence of surgical site infections (Kopp et al., 2015). Finn et al. (2016) conducted a retrospective analysis of patients undergoing total knee and total hip arthroplasty and the impact of continuous PNB on mechanical falls and found that the risk for mechanical fall increased at their institution, but could not apply these results to single shot PNB based on study limitations (specifically the use of continuous catheter PNB and not single shot PNB). The evidence described above suggests that the use of PNB has a relatively low risk of compartment syndrome, mechanical fall, infection, and peripheral nerve injury. Using these data helps to support the possibility that utilizing PNB for tibial plateau fractures will be safe, thus making relevant the further exploration of a possible decrease on total opioid usage, hospital length of stay, and other factors related to PNB use in the operative fracture patient population.
Tibial plateau fractures are injuries to the proximal tibia that can occur in low- or high-energy mechanisms, varying in their severity based on energy pattern and the age of the patient (Mills & Nork, 2002). In patients who experience a physical trauma with an associated tibial plateau fracture, a global patient perspective is required, because patient health status and other injuries contribute to the long-term surgical management decisions that are required for the tibial plateau fracture (Roberts et al., 2005). At one level 1 trauma center teaching hospital in the Midwest (study hospital), patients undergoing operative repair of tibial plateau fractures can expect to spend a minimum of 2 days admitted to the hospital and at least 12 weeks spent non-weight bearing on the side of injury. Managing pain following the surgery is one of the primary goals prior to discharge to home or a skilled rehabilitation facility. An evaluation of the use of current pain management techniques such as PNB for the use of fractures can be evaluated longitudinally to determine if this procedure has in fact been increasing in use at our institution. In doing this, potential correlations between hospital length of stay, frequency of PNB use for fracture repair, and potential links to surgeon specific trends can be assessed.

When examining use of PNB in tibial plateau fractures in clinical settings, addressing potential confounders such as the use and/or abuse of opioids, patient demographics and comorbidities, along with smoking status, are vital. In one study, non-Hispanic White adolescents were significantly more likely to participate in the non-medical use of prescription opioids than other races/ethnicities (Vaughn, Nelson, Salas-Wright, Qian, & Schootman, 2016). Smoking has been linked to a higher incidence of opioid dependence/abuse (Hooten, Shi, Gazelka, & Warner, 2011).
Given current knowledge regarding the ability to treat pain in fractures, this dissertation aims to examine the following issues. The issues include an assessment of opioid prescriptions after surgery with PNB versus no PNB while controlling for race/ethnicity and other potential confounders, long-term opioid prescription patterns of certain patient populations, and an evaluation of trends in PNB use at a single level 1 institution over time, along with potential differences based on surgeon preference in the use of PNB following operative fixation of tibial plateau fractures. These research topics are assessed in detail in chapters 2, 3, and 4 of this manuscript.

Chapter 2 specifically looks at whether short- and long-term opioids prescriptions are lower with PNBs compared to non-PNBs with tibial plateau fractures and examines whether PNBs can be used to reduce hospital length of stay. Fracture type is examined along with the impact of smoking, race/ethnicity, age, gender, and BMI on opioid use and hospital length of stay.

Chapter 3 expands on results obtained in Chapter 2 regarding differences by race/ethnicity. To better understand if other confounding factors could be attributed to the race/ethnicity differences found with long-term opioid use (3 and 6 months), results are further stratified by age, gender, BMI, and smoking status.

Chapter 4 expands on results obtained in Chapter 2 by expanding from tibial plateau fractures to all lower extremity fractures. In doing so, this chapter seeks to determine if creating a dedicated PNB team has increased the rate of PNB use over the last 10 years. Chapter 4 also examines if PNB use in lower extremity fractures over the last 10 years was associated with a significant decrease in hospital length of stay compared to no PNB.
References


Harris, B. R. (2016). Talking about screening, brief intervention, and referral to treatment for adolescents: An upstream intervention to address the heroin and prescription opioid epidemic. *Preventive Medicine, 91*, 397-399.


CHAPTER 2

UTILITY OF PERI-OPERATIVE REGIONAL NERVE BLOCK (PNB) IN TIBIAL PLATEAU FRACTURES: AN ASSESSMENT OF POST-OPERATIVE PAIN AND OTHER PATIENT FACTORS

Background

Pain is a subjective phenomenon that varies from person to person, with bone (fracture) pain being caused from hyper-activation of nociceptors in the periosteal layer and the bone marrow, which send signals to the brain, thus leading to the sensation of pain (Luger et al., 2005). The pain resulting from fractures frequently requires the use of opioids (Lindenhovious et al., 2009). Opioids are considered the mainstay for patient relief and comfort following fractures (Ritsema et al., 2007). Opioid pain medications are not benign and have various associated side effects including sedation, nausea, vomiting, pruritus/anaphylaxis, urinary retention/constipation, respiratory depression, and, in some cases, death (Baldini et al., 2012). In 2015, more than 15,000 U.S. citizens died from overdoses involving prescription opioids (Rudd, Seth, David, & Scholl, 2016). This prompted The Joint Commission to release a sentinel event alert for the safe use of opioids (“Safe Use of Opioids in Hospitals,” 2012). The American Society of Anesthesiology (ASA) recognizes this risk and advocates the use of regional or local anesthesia to minimize opioid use (Apfelbaum et al., 2012). There is also a risk of dependence that comes with chronic opioid use, which has been well documented (Ballantyne & LaForge, 2007). Patients with fractures are particularly at risk compared to the general population for developing tolerance, addiction, and abuse when prescribed opioids because of the need to
control their pain following injury (Manchikanti et al., 2012). Approximately 52,000 drug overdoses were documented in 2015, and 63% of those cases involved the use of an opioid (Rudd et al., 2016). In 2009, approximately 2.2 million people in the U.S. initiated their drug use with opioid pain relievers (UN Office on Drugs and Crime [UNODC], 2011).

Because of the consequences, alternative methods to opioid use should be considered (Rudd et al., 2016). Pain relievers such as non-steroidal anti-inflammatory drugs (NSAIDs) have great applications for the treatment of pain; however, these medications have limited practicality in patients with fractures because NSAID use has been shown to delay healing and cause fracture nonunion in humeral, femoral, and tibial shaft fractures (Bhandari et al., 2003; Bhattacharyya, Levin, Vrahos, & Solomon, 2005; Giannoudis et al., 2000). Multiple reports have shown that failure to heal a fracture results in higher rates of infection, chronic pain, hardware failure, and re-operation (Bhandari, Guyatt, Swiontkowski, & Schemitsch, 2001; Fong et al., 2013). A recent study concluded that patients with long bone fractures who received NSAIDs in the post-operative period were twice as likely as those who received no NSAIDs to suffer complications such as nonunion/malunion or infection (Jeffcoach et al., 2014). Biological evidence also supports the known clinical evidence with NSAIDs found to inhibit Cyclooxygenase 2 function and angiogenesis, both crucial components to bone healing (Murnaghan, Li, & Marsh, 2006; Simon, Manigrasso, & O’Connor, 2002).

However, in those with bone fractures, acute pain control can be achieved with a regional nerve block (Chelly, Ghisi, & Fanelli, 2010). A peri-operative regional nerve block (PNB) is accomplished by injecting local anesthetic (bupivacaine, rupivacaine, or lidocaine) adjacent to one or more peripheral nerves supplying the area of the fracture to decrease pain (Fowler,
Symons, Sabato, & Myles, 2008). Common peri-neural anesthesia sites for hip and knee surgeries include parasacral, sciatic nerve, lumbar plexus blocks, 3:1 femoral nerve blocks, and iliacus blocks (Nicholls, 2007). PNBs may be performed and administered in a single dose, or left in place via a catheter and dosed repeatedly for 24-72 hours (Nicholls, 2007).

Efficacy and appropriateness of PNB for patients with fractures has been the topic of recent literature, as shown in Table 2.1. Although certain fracture patterns may occur more commonly, each fracture has particular concerns with various management options (Barei, O’Mara, Taitsman, Dunbar, & Nork, 2008). Trauma patients often present with additional factors that may alter timing, operative decisions, anesthesia technique, and post-operative protocols such as weight-bearing status (Roberts et al., 2005). Fractures tend to occur with concomitant surrounding soft tissue injury, and occasionally neurovascular injury (Tull & Borelli, 2003). Severe swelling can cause an increased risk for compartment syndrome, particularly in the lower leg (McQueen & Gaston, 2000). In theory, regional nerve blockade can prevent the ability to detect an impending or active compartment syndrome due to decreased sensation in the upper or lower extremity. There have been case reports of decreased recognition of compartment syndromes in fracture patients who received nerve blocks, but this is rare (Cometa, Esch, & Boezaart, 2011; Mar, Barrington, & McGuirk, 2009).

McQueen and Gaston (2000) reported on 164 patients with acute compartment syndrome over an 8-year period and 69% were associated with a fracture, with approximately 50% of those involving the tibial shaft. Because tibia fractures are uniquely responsible for a large number of compartment syndrome cases and because there have been case reports of
decreased recognition of compartment syndromes in fracture patients, a unique question arises: Is there a significant clinical benefit to PNB in patients with tibial plateau fractures?

Table 2.1

Summary of Studies That Examined Peri-Operative Regional Nerve Block (PNB) Use for Lower Extremity Fractures

<table>
<thead>
<tr>
<th>Population</th>
<th>Intervention</th>
<th>Comparison</th>
<th>Outcome</th>
<th>Study Type/ Quantity</th>
<th>Author(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Femur Fractures</td>
<td>PNB (Single Shot)</td>
<td>No PNB</td>
<td>• ↓ Inpatient opioids</td>
<td>Prospective 41 patients</td>
<td>Diakomi, Papaioannou, Mela, Kouskouni, &amp; Makris, 2014</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• ↓ Pain scores</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• ↑ Pt satisfaction</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Talus/Calcaneus Fractures</td>
<td>PNB (Catheter)</td>
<td>No PNB with PCA</td>
<td>• 30 times less opioid required</td>
<td>Retrospective 87 patients</td>
<td>Luiten et al., 2014</td>
</tr>
<tr>
<td>Ankle Fractures</td>
<td>PNB (Single Shot) with Spinal</td>
<td>PNB (Single Shot) with GA No PNB with GA or Spinal</td>
<td>• 30% ↓ opioid use</td>
<td>Retrospective 622 patients</td>
<td>Christensen, Møller, Nielsen, Klausen, &amp; Sort; 2015</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• ↓ Rebound pain</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• ↓ 72 hour opioid use</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• ↓ Pain scores at 2 and 12 weeks</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>PNB (Catheter)</td>
<td>PNB (Single Shot)</td>
<td>• ↑ Perception of pain relief</td>
<td>Prospective 50 patients</td>
<td>Ding, Manoli, Galos, Jain, &amp; Tejwani, 2015</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• ↓ 24 hr severe pain</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• ↑ QOR (24 hours)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• = QOR (48 hours)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note. PNB = Peri-operative regional nerve block; GA = General anesthesia; QOR = Quality of recovery; PCA = Patient controlled anesthesia.
Based on current published literature, no prospective or retrospective analyses exist evaluating the efficacy, safety, or utility of PNB in tibial plateau fractures. Efficacy is defined by post-operative pain control and total opioid use after surgical fixation. Further attention to the topic of PNB use in tibial plateau fracture patients should be performed to make specific recommendations to the orthopaedic and anesthesia communities to improve patient treatment options. An analysis of the use of PNB on tibial plateau fractures was conducted. The primary research question was as follows: Is PNB for tibial plateau fractures associated with post-operative opioid usage, inpatient length of stay, or readmission?

**Method**

This study was a retrospective analysis of medical records from a level 1 trauma center from January 1, 2006 through December 31, 2015. This institution sees over 300 operative tibial plateau fractures annually, according to EPIC data mining. Additionally, the anesthesia team performs thousands of PNB procedures annually.

Data were gathered in an encrypted, password-protected drive from the medical center’s electronic medical record system and HIPAA compliance was maintained throughout. Human Subjects Institutional Review Board (HSIRB) approval was obtained from Loyola University Medical Center and Western Michigan University. Beginning April of 2015, the following search terms were used for the literature review: fracture AND regional anesthesia, tibial fracture AND regional anesthesia, tibial fracture AND peripheral anesthesia, tibial fracture AND nerve block, plateau fracture AND pain, using Scopus and Web of Science. Scopus and Web of Science automatic notifications were set to continuously provide updates as new literature was published meeting the search terms used above.
Inclusion criteria for this study included being a patient ages 18-65 who sustained a tibial plateau fracture and underwent operative repair at Loyola University Medical Center. Exclusion criteria included those patients less than 18 or older than 65, American Society of Anesthesiologists (ASA) physical status of more than class 3, history of opioid dependence, current chronic opioid use (daily use > 4 weeks), rheumatoid arthritis, allergy to study medications, preexisting lower extremity neurologic impairment, and known hepatic or renal impairment restricting pain control options. These criteria were applied to control for patient severity and attempt to mitigate the differences that could be seen between trauma and elective surgical patients.

Dependent variables included post-operative day zero, one, two, and three-day total morphine equivalent dose calculated based on previously accepted method in the literature (Bot, Bekkers, Arnstein, Smith, & Ring, 2014; Gammaitoni, Fine, Alvarez, McPherson, & Bergmark, 2003; Patanwala, Duby, Waters, & Erstad, 2007; Svendsen et al., 2011). Other dependent variables included total inpatient length of stay, opioid use at 3 and 6 months, and any unplanned follow up (consisting of an ER visit, clinic visit, or hospital admission, prior to the first post-operative visit).

For the study, patients were classified as those who received PNB (single shot) or received no block (control) as the primary independent variable. In addition to PNB status (single shot PNB vs. no PNB), other potential confounding variables included tibial plateau fracture type (unicondylar vs. bicondylar), body mass index (BMI, < 30 vs. ≥ 30), race/ethnicity (White, Black, Hispanic), gender (male vs. female), current smoking status (yes vs. no), and age.
(in years). Other races/ethnicities were excluded at baseline as there were not enough in the population sample to detect significant differences.

Data were analyzed using IBM SPSS version 24 (Chicago, IL) statistical software. Normality of distribution was calculated for continuous variables using Kolmogorov–Smirnov (KS) and Shapiro Wilk tests and by examining skewness and kurtosis. Analyses were conducted using Pearson chi-square, repeated measures ANOVA with Bonferroni post hoc correction, and independent samples t tests. Results were considered significant at $p < .05$, with confidence intervals set at 95%.

Results

Ten years of data (2006-2015) were examined from a level 1 trauma center and 315 operative tibial plateau fractures were identified. Ninety-nine patients were excluded, leaving a final sample size of 216 (122 unicondylar and 94 bicondylar fractures). See Table 2.2 for details regarding exclusions.

In patients who underwent tibial plateau fracture repair, there was less opioid use on the day of surgery in the single shot PNB group compared to the no block group ($p = .044$, $t = 2.028$, mean difference = 27.109, 95% CI (.766, 53.452), $df = 1$) (Figure 2.1). There were no significant variations among PNB use and opioid use between post-operative days 0, 1, and 2 ($p = .327$, $F = .979$, $df = 1$). There was a significant variation among no PNB use between post-operative days 0, 1, and 2 ($p = .013$, $F = 6.369$, $df = 1$). Post hoc Bonferroni analyses demonstrate that the difference detected in the no PNB groups was between post-operative day zero and post-operative day two ($p = .038$, mean difference = 17.774, 95% CI (.737, 34.810). See Figure 2.1 for post-operative outcome measures by PNB status.
Table 2.2

Participants by Study Exclusion Criteria

<table>
<thead>
<tr>
<th>Participants Excluded</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;18 y/o</td>
<td>2</td>
</tr>
<tr>
<td>&gt;65 y/o</td>
<td>38</td>
</tr>
<tr>
<td>Pre-injury opioid use</td>
<td>18</td>
</tr>
<tr>
<td>History of opioid dependence</td>
<td>2</td>
</tr>
<tr>
<td>ASA class ≥ 3</td>
<td>9</td>
</tr>
<tr>
<td>Hepatic or renal impairment</td>
<td>4</td>
</tr>
<tr>
<td>History of lower extremity neurological impairment</td>
<td>4</td>
</tr>
<tr>
<td>Rheumatoid arthritis</td>
<td>2</td>
</tr>
<tr>
<td>No anesthesia record</td>
<td>4</td>
</tr>
<tr>
<td>Received catheter PNB</td>
<td>9</td>
</tr>
<tr>
<td>Received both single shot and catheter PNB</td>
<td>7</td>
</tr>
<tr>
<td>Total Excluded</td>
<td>99</td>
</tr>
</tbody>
</table>

Note. ASA = American Society of Anesthesiologists, Class 3 = Severe systemic disturbance from any cause or causes; PNB = Peri-operative regional nerve block.

Figure 2.1. PNB status by percent prescribed opioids 0-3 days post-operatively (POD 0: \( p = .044; t = 2.028 \); mean difference = 27.109; 95% CI (.766, 53.452); \( df = 1 \)) between PNB and no PNB groups.
Hospital length of stay was 2.8 days less following tibial plateau fracture in the single shot PNB group compared to the no block group (\(p = .003, t = 2.990\), mean difference = 2.812, 95% CI (.952, 4.672) (Table 2.3). PNB status was not associated with opioid use at 3 months (\(p = .218, \chi^2 = 1.520, df = 1\)) or 6 months (\(p = .194, \chi^2 = 1.686, df = 1\)) (Table 2.3). No association was found between PNB status and unplanned follow up or readmission rate (\(p = .639, \chi^2 = .220, df = 1\)) (Table 2.3). None of the surgical cases developed compartment syndrome in the control or treatment group and, therefore, no missed cases of compartment syndrome due to PNB were identified. See Table 2.3 for outcome post-operative outcomes by PNB status.

Table 2.3

Post-Operative Outcomes by PNB Status Following Tibial Plateau Fracture Repair

<table>
<thead>
<tr>
<th></th>
<th>PNB</th>
<th>No PNB</th>
<th>Sig*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>n (%)</td>
<td>n (%)</td>
</tr>
<tr>
<td>Opioid Use at 3 Months</td>
<td>216</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>80</td>
<td>23 (44.2%)</td>
<td>57 (34.8%)</td>
</tr>
<tr>
<td>No</td>
<td>136</td>
<td>29 (55.8%)</td>
<td>107 (65.2%)</td>
</tr>
<tr>
<td>Opioid Use at 6 Months</td>
<td>216</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>28</td>
<td>4 (7.7%)</td>
<td>24 (14.6%)</td>
</tr>
<tr>
<td>No</td>
<td>188</td>
<td>48 (92.3%)</td>
<td>140 (85.4%)</td>
</tr>
<tr>
<td>Unplanned Follow Up</td>
<td>216</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>11</td>
<td>2 (3.8%)</td>
<td>9 (5.5%)</td>
</tr>
<tr>
<td>No</td>
<td>205</td>
<td>50 (96.2%)</td>
<td>155 (94.5%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>PNB</td>
<td>No PNB</td>
<td>Sig*</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>Average (SD)</td>
<td>Average (SD)</td>
</tr>
<tr>
<td>Hospital LOS</td>
<td>216</td>
<td>4.48 (5.112)</td>
<td>7.29 (7.914)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note. PNB = Peri-operative regional nerve block; SD = Standard deviation; LOS = Length of stay.
*p < .05; 95% Confidence Intervals; \(\chi^2\) (categorical); t test (continuous).
Individuals were significantly more likely to receive a single shot PNB if they sustained a unicondylar tibial plateau fracture versus a bicondylar tibial plateau fracture ($p = .033$, OR = 2.04, $\chi^2 = 4.53$, df = 1) (Table 2.4). Overall, 29.5% of unicondylar tibial plateau fractures received PNB compared to only 17% of bicondylar tibial plateau fractures. However, fracture type didn’t have an association with opioid use or length of hospital stay. Race/ethnicity ($p = .480$, $\chi^2 = 1.486$, df = 1), smoking status ($p = .580$, $\chi^2 = .307$, df = 1), gender ($p = .566$, $\chi^2 = .329$, df = 1), and BMI ($p = .578$, $t = .557$, df = 211) did not have an association with PNB use or non-use (Table 2.4). See Table 2.4 for demographic and anthropometric characteristics by PNB status.

White patients who underwent tibial plateau fracture repair were more likely than other races/ethnicities to be prescribed opioids at 3 months ($p = .048$, $\chi^2 = 6.078$, df = 2) and 6 months ($p = .049$, $\chi^2 = 6.032$, df = 2) (Table 2.5). Among White patients, 42.1% were still receiving opioid pain medication at 3 months, compared to 42.1% of Hispanic patients and 23.1% of Black patients (Table 2.5). At 6 months, White patients were still prescribed opioids at a rate of 18.2%, compared to 7.9% of Hispanics and 5.8% of Black patients (Table 2.5). In patients who underwent tibial plateau fracture repair, a higher number of patients who smoked were still prescribed opioids at 6 months (19.8%) compared to non-smokers (8.5%) ($p = .015$, OR = 1.20, $\chi^2 = 5.68$, df = 1) (Table 2.5).
Table 2.4

Demographic and Anthropometric Characteristics by PNB Status Following Tibial Plateau Fracture Repair

<table>
<thead>
<tr>
<th></th>
<th>PNB</th>
<th>No PNB</th>
<th>Sig*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>n (%)</td>
<td>n (%)</td>
</tr>
<tr>
<td>Race/Ethnicity</td>
<td>211</td>
<td></td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>121</td>
<td>28 (23.1%)</td>
<td>93 (76.9%)</td>
</tr>
<tr>
<td>Black</td>
<td>52</td>
<td>11 (21.2%)</td>
<td>41 (78.8%)</td>
</tr>
<tr>
<td>Hispanic</td>
<td>38</td>
<td>12 (31.6%)</td>
<td>26 (68.4%)</td>
</tr>
<tr>
<td>Smoking Status</td>
<td>216</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>130</td>
<td>33 (25.4%)</td>
<td>97 (74.6%)</td>
</tr>
<tr>
<td>Yes</td>
<td>86</td>
<td>19 (22.1%)</td>
<td>67 (77.9%)</td>
</tr>
<tr>
<td>Fracture Type</td>
<td>216</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unicondylar</td>
<td>122</td>
<td>36 (29.5%)</td>
<td>86 (70.5%)</td>
</tr>
<tr>
<td>Bicondylar</td>
<td>94</td>
<td>16 (17.0%)</td>
<td>78 (83.0%)</td>
</tr>
<tr>
<td>Gender</td>
<td>216</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>136</td>
<td>31 (22.8%)</td>
<td>105 (77.2%)</td>
</tr>
<tr>
<td>Female</td>
<td>80</td>
<td>21 (26.3%)</td>
<td>59 (73.8%)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>PNB</th>
<th>No PNB</th>
<th>Sig*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>Average (SD)</td>
<td>Average (SD)</td>
</tr>
</tbody>
</table>

Note. PNB = Peri-operative regional nerve block; SD = Standard Deviation; BMI = Body mass index. *p < .05; 95% Confidence Intervals; $\chi^2$ (categorical); $t$ test (continuous).
Table 2.5

Demographic Characteristics by Long-Term Opioid Use Status Following Tibial Plateau Fracture Repair

<table>
<thead>
<tr>
<th></th>
<th>On Opioids at 3 Months</th>
<th></th>
<th>On Opioids at 6 Months</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>n (%)</td>
<td>n (%)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>211</td>
<td></td>
<td>22</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(\chi^2 = 6.078) (p = .048)</td>
<td>(\chi^2 = 6.032) (p = .049)</td>
<td></td>
</tr>
<tr>
<td>Race/Ethnicity</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>121</td>
<td>51 (42.1%)</td>
<td>22 (18.2%)</td>
<td></td>
</tr>
<tr>
<td>Black</td>
<td>52</td>
<td>12 (23.1%)</td>
<td>3 (5.8%)</td>
<td></td>
</tr>
<tr>
<td>Hispanic</td>
<td>38</td>
<td>16 (42.1%)</td>
<td>3 (7.9%)</td>
<td></td>
</tr>
<tr>
<td>Smoking Status</td>
<td>216</td>
<td></td>
<td>11</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(\chi^2 = .821) (p = .365)</td>
<td>(\chi^2 = 5.864) (p = .015)</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>130</td>
<td>45 (34.6%)</td>
<td>11 (8.5%)</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>86</td>
<td>35 (40.7%)</td>
<td>17 (19.8%)</td>
<td></td>
</tr>
<tr>
<td>Fracture Type</td>
<td>216</td>
<td></td>
<td>13</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(\chi^2 = .386) (p = .535)</td>
<td>(\chi^2 = 1.323) (p = .250)</td>
<td></td>
</tr>
<tr>
<td>Unicondylar</td>
<td>122</td>
<td>43 (35.2%)</td>
<td>13 (10.7%)</td>
<td></td>
</tr>
<tr>
<td>Bicondylar</td>
<td>94</td>
<td>37 (39.4%)</td>
<td>15 (16.0%)</td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td>216</td>
<td></td>
<td>19</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(\chi^2 = .226) (p = .634)</td>
<td>(\chi^2 = .330) (p = .565)</td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>136</td>
<td>52 (38.2%)</td>
<td>19 (14.0%)</td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>80</td>
<td>28 (35.0%)</td>
<td>9 (11.3%)</td>
<td></td>
</tr>
</tbody>
</table>

Note. SD = Standard deviation.
*p < .05; 95% Confidence Intervals; \(\chi^2\) (categorical); t test (continuous).

Discussion

In patients undergoing tibial plateau fracture repair, single shot PNB may reduce hospital length of stay and decrease day of surgery opioid use compared to no PNB, but may cause an increase (or at least a lack of a decrease) in post-operative day one requirements if not controlled for with anticipatory oral opioids. A decrease in opioid use could indicate that
PNBs are in fact efficacious when it comes to treating post-operative pain in these patients, therefore limiting the need for additional opioids after awaking from anesthesia. While the average opioid use for those who received PNB rose 15.9 mg (74.1 to 90.0) from day zero to day one, the average use for those not on PNB decreased 15.2 mg (101.2 to 86.0) from day zero to day one. This difference, however, was not statistically significant. The average increase in pain medication requirements on post-operative day one is known as rebound pain, a phenomenon that occurs when the PNB begins to wear off and could be due to the fact the patient is unprepared for the onset of pain and has not been given an anticipatory load of oral opioids (Capdevila et al., 2005).

It was also found that those patients who sustained a unicondylar fracture were more likely to receive a PNB compared to those who sustained a bicondylar fracture. This could be explained by higher energy trauma and the potentially higher risk for compartment syndrome, as determined by the surgeon, and thus dissuading them from allowing a PNB for pain control, but fracture type was not associated with any medication or hospital-related outcomes, so this is unlikely to be the reason for findings.

Unanticipated findings of this research were that White patients undergoing tibial plateau fracture repair were more likely to receive higher doses of opioids at 3- and 6-month follow-up appointments compared to other races/ethnicities. This result raises questions of why there would be varying post-operative opioid prescription patterns by race/ethnicity of the patient. No real inferences are made here, but rather a note for further exploration.

Following surgery, smokers were over 10% more likely to be receiving opioid prescriptions at 6 months post-operatively compared to non-smokers, a finding that was not
found at the 3-month post-operative visit. As described earlier, smoking has been found to be associated with higher rates of opioid use, and this research re-emphasizes this relationship (Hooten, Shi, Gazelka, & Warner, 2011).

In this study, no case of compartment syndrome occurred for the PNB group or the no block group; therefore, there were no cases of compartment syndrome that were missed as a result of PNB. Although this study was not powered to identify this rare complication, it may be reassuring to those considering use of PNB for patients with tibial plateau fractures in the future. However, risks should still be carefully considered and each patient evaluated on an individual basis, and weighed with the risks associated with opioid use and abuse.

The risks of opioid use and abuse continue to be seen and identified clinically, and with the exception of codeine, medical use of prescription opioids continues to contribute to increases in opioid misuse and other related health consequences (Atluri, Sudarshan, & Manchikanti, 2014). New data from the Centers for Disease Control and Prevention (CDC) assessed the 10-year time period (2006-2015) and found that despite decreases in the quantity of opioids prescribed in the United States between 2010 and 2015, the quantity prescribed in 2015 is still three times higher than the amount prescribed in 1999 (Guy, 2017). Limiting opioid use based on known risk factors for addiction may also play a role in reducing opioid abuse. Factors such as smoking and depression have been found to be associated with higher incidence of opioid dependence/abuse (Hooten et al., 2011). Ultimately, understanding these risk factors helps connect this research of preventing and treating pain control with the ability to reduce dependency on opioid pain medication in the short and long term.
The PNB has been successfully applied by many orthopaedic specialties, especially joint reconstruction (Lee, Tey, & Chua, 2012; MacFarlane, Arun Prasad, Chan, & Brull, 2009). One study demonstrated that immediately after surgery, there was less pain, higher satisfaction, and lower morphine use among patients on continuous femoral nerve block compared to PCA alone (Shum et al., 2009). This tool for pain control is a viable option that requires continued exploration in the orthopaedic trauma community.

Strengths of this study included the non-invasive nature of retrospective design and 10 years of data at one institution utilizing five fellowship-trained orthopaedic surgeons. Including over 200 patients in the study provided enough power to detect differences among groups. Limitations of this study include the lack of randomization due to the retrospective design. Although potential confounding factors such as smoking, race/ethnicity, and age were examined, patient co-morbidities, alcohol use, illicit drug use, socioeconomic status, compliance with post-operative treatment protocols (non-weight bearing and physical therapy adherence), severity of injury pattern, and other concomitant injuries were not included in this study and the small cell sizes made controlling for some potential confounders difficult. However, baseline patient sampling in the study design eliminated many of the high acuity patients by controlling for ASA class, extreme age spectrums, comorbidities, and those patients with a history of opioid use, thus diminishing the potential differences between emergent and elective surgeries. For instance, in order to have adequate sample size, a broad age range was used in study inclusion criteria; however, age was not associated with any difference in opioid pain use in this study among those ages included.
Another potential confounder could be the discretionary dosage of pain medication given to patients by the attending physician or the orthopaedic surgery resident in training. At this institution, hydrocodone/acetaminophen 10/325 mg every 4 to 6 hours is routinely used for the vast majority of patients, and this is adjusted lower or higher depending on individual patient needs and/or history. There is certainly variability between prescribers; however, standard pain regimens were provided for all patients. Therefore, varying prescribing practices in the hospital should not have played a significant factor in the outcomes of this particular study.

There may also be some selection bias in that only patients who had a limited amount of swelling and, therefore, lower presumed risk for compartment syndrome were considered for regional nerve blocks. The chronic pain measure was arbitrarily set at 3 and 6 months, and although prescriptions were written, there is no quantifiable way to guarantee that each of these patients was taking their medication. Finally, an inability to compare single shot PNB to catheter PNB due to the small number receiving a catheter PNB is a study limitation that warrants additional exploration considering the success other research has documented with the use of catheter PNB in orthopaedics (Ilfeld et al., 2010).

In conclusion, this retrospective study analyzed 10 years of tibial plateau fracture repairs at a single institution and found that patients had a shorter hospital length of stay and decreased day of surgery opioid requirement when given a single shot PNB compared to no PNB. Our findings did not find a statistically significant increase in opioid use in PNB group at day 1; however, the pattern in mean opioid use for this group could be considered consistent with previous findings that PNB could result in a spike in opioid requirements on day one post-
surgery, but this result in our study could have been by chance alone, since it was not significant (Capdevila et al., 2005). Given these results, it might be helpful to have a transition plan in place for oral opioid therapy. These data may provide an additional tool for the surgeon with few options for alleviating fracture pain. This information provides value to the anesthesia team in managing peri-operative pain.

Future research using a multi-center, prospective comparison of single shot PNB to continuous PNB could provide great value to future clinical outcomes. In 2016, a comparison study of spinal anesthesia versus general anesthesia for management of tibial plateau fractures in humans was conducted and found that the use of spinal anesthesia is associated with decreased pain levels in the early post-operative period; however, there was no effect on functional assessment scores (Manoli, Atchabahian, Davidovitch, & Egol, 2016). Combination studies of the above may also be feasible in future research.

The orthopaedic and anesthesia community should work together to provide the best patient care available. This evidence suggests that PNB may be safe and effective in managing pain and reducing hospital length of stay in those undergoing operative fixation of tibial plateau fractures. Providers should examine rates of opioid prescription in their population, including by race/ethnicity and smoking status to identify trends and ensure consistent evidence-based protocols are in place. In using PNB, a pre-emptive opioid treatment protocol should be in place so as to lessen the effects of potential rebound pain once the PNB is complete.

References


nerve block obscure the diagnosis or delay the treatment of acute lower leg compartment syndrome? A case report. *Pain Medicine, 12*, 823-828.


CHAPTER 3

AN ASSESSMENT OF LONG-TERM OPIOID USE FOLLOWING TIBIAL PLATEAU FRACTURE REPAIR: AN AT-RISK PATIENT POPULATION BASED ON RACE/ETHNICITY

Background

Questions about long-term prescribing patterns and trends specifically regarding race/ethnicity were raised in Chapter 2 in relation to tibial plateau fractures and post-operative pain management, specifically that patients who were White were more likely to still have opioid prescriptions at 3 and 6 months post-surgery compared to patients who were Black. Other literature based on self-reported surveys found that when considering the non-medical use of prescription opioids (NMUPO) (using opioid medications for purposes other than the reason prescribed), non-Hispanic White youth reported significantly higher use than other races/ethnicities, although these data were not necessarily following surgery (Vaughn, Nelson, Salas-Wright, Qian, & Schootman, 2016). This type of research further supports assessing racial and ethnic differences in how pain management is achieved, specifically, attempting to determine what are the possible causes for these differences and how can they be addressed. Furthermore, it is important to establish the significance and extent of opioid use and abuse in the United States.

As of data collected through 2015, in the United States, 42 people die every day as a result of prescription opioid overdose (Centers for Disease Control and Prevention [CDC], 2017). The expansion of treatment providers, programs, and options for addicts is thus of significant
concern. Addressing prescribing patterns and addiction behaviors may assist in the ability to prevent future opioid use/addiction. Attempting to comprehend prescribing patterns may also provide insight into cultural norms and stereotypes with regard to addiction and preventing addiction behavior.

According to the Centers for Disease Control and Prevention (CDC, 2017), deaths from opioid use quadrupled between 1999 and 2010, and in 2015, approximately 15,000 of these deaths (approximately half) were a result of prescription opioid use. In 2014, almost two million Americans abused or were dependent on prescription opioids (CDC, 2017). There is a known risk of dependence that comes with chronic opioid use, which has been documented in the U.S. (Ballantyne & LaForge, 2007). Over the last 10 years, there has been an increasing level of opioid addiction and abuse by patients and, in some cases, medical providers (Berge, Seppala, & Schipper, 2009). Additionally, those addicted to prescription opioids have been found to have an increased risk of abusing non-prescription opioids in the future (UN Office on Drugs and Crime [UNODC], 2011). These findings highlight the need to uncover additional or alternative options with regard to pain management in an effort to decrease nationwide opioid prescription and potentially opioid-related morbidity/mortality.

For all racial/ethnic groups, there are likely a myriad of factors as to why opioid prescriptions are on the rise. These may be ethical and highly subjective in nature, for example, the willingness of medical providers to prescribe or not prescribe patients what they want. For these reasons, trying to uncover certain prescribing patterns or demographic patterns by factors such as race/ethnicity in opioid use may provide light on other epidemiologic research examining risk factors for opioid use/dependence. One such study that examined over 700
patients with chronic low back pain and evaluated differences in treatment regimens, found that 60% of the patients had been treated with opioids in the last month and concluded that despite frequent treatments for chronic low back pain, these treatment patterns are variable with consistent overutilization of medications and underutilization of exercise and depression treatment (Carey et al., 2009). This highlights that some individuals may be more likely to require opioids and intentionally or unintentionally remain on these medications for longer periods. Understanding patterns related to opioid use is important to combat these increasing trends of use and abuse.

There are also areas for improvement in understanding the pain needs of patients. One study found that in 275 patients, 67% of these patients had surplus medication from the initial post-operative prescription and 92% received no disposal instructions for surplus medication (Bates, Laciak, Southwick, & Bishoff, 2011). Lewis, Cucciare, and Trafton (2014) looked at surplus opioid prescriptions in 191 veterans and found that 65.4% of these individuals retained these medications even after stopping the opioid, and there were some reports of large accumulations of opioids by participants. This information suggests that patient factors also play a role in their own management of pain and that providers need to do a better job estimating and accounting for total opioid use among patients for whom they prescribe these opioids.

In patients who underwent tibial plateau fracture repair, our prior study results indicated that White patients were being prescribed higher doses of opioids on post-operative day one and were more likely than other races/ethnicities to be prescribed opioids at 3 and 6 months post-operatively. Because our previous study noted higher rates of long-term opioid
use in smokers and differences among races/ethnicities, smoking status was stratified with race/ethnicity to uncover potential confounders and interactions among variables.

Additional literature review was also performed to assess current and past findings regarding race/ethnicity and pain management. There were multiple articles that described Black patients being less likely to be prescribed medications to control pain, and when these medications were prescribed, they tended to receive lower doses/amounts (Anderson, Green, & Payne, 2009; Cintron & Morrison, 2006; Goyal, Kuppermann, Cleary, Teach, & Chamberlain, 2015; Shavers, Bakos, & Sheppard, 2010). More specifically, in one large study assessing children with appendicitis in emergency departments, when compared to White children, Black children were less likely to be treated with pain medication in general, and also less likely to receive opioids for severe pain (Goyal et al., 2015). Some research has suggested that physicians may have concerns about patient noncompliance or full access to the healthcare system, thus making them less likely to treat Black patients’ pain adequately or at all (Shavers et al., 2010). More perplexing, multiple authors have suggested that some people in this country may hold assumptions that Black patients do not feel as much pain as Whites, or rather Blacks have higher pain tolerances, which could contribute to the overall disparity in willingness to treat Black patients’ pain adequately (Hoffman & Trawalter, 2016; Mathur, Richeson, Paice, Muzyka, & Chiao, 2014; Trawalter, Hoffman, & Waytz, 2012; Wandner, Scipio, Hirsh, Torres, & Robinson, 2012; Waytz, Hoffman, & Trawalter, 2015).

As a result of our findings and other related findings in the literature regarding race/ethnicity, further exploration was conducted to assess long-term opioid use by race/ethnicity while taking into consideration other potential confounders, including gender,
BMI, smoking status, fracture type, and unplanned follow-up/readmission. The primary research question for this study was: Is there a difference in percentage of opioid use at 3 and 6 months among different races/ethnicities following tibial plateau fracture repair after controlling for potential confounders?

**Method**

This study was a retrospective analysis of medical records from a level 1 trauma center, Loyola University Medical Center, from January 1, 2006 through December 31, 2015. The anesthesia team or “Block Team” performs thousands of peri-operative regional nerve blockade procedures annually, making this institution a relevant choice for comparing those receiving PNB.

All of the data collected for this research were stored and encrypted in a HIPAA-compliant software at Loyola University Medical Center. This software is password-protected and limited access is provided only to authorized users from the institution. Human Subjects Institutional Review Board (HSIRB) approval was obtained from both Loyola University Medical Center and Western Michigan University for this study.

The literature review was conducted using the following search terms: fracture AND regional anesthesia, tibial fracture AND regional anesthesia, tibial fracture AND peripheral anesthesia, tibial fracture AND nerve block, plateau fracture AND pain, surgery PLUS opioid use AND race, opioid use AND ethnicity, addiction AND race, addiction AND ethnicity, pain control AND race, pain control AND ethnicity, using the same databases mentioned in Paper One (Chapter 2), which included Scopus and Web of Science. These searches were initiated April
Automatic notifications were set to provide monthly updates indefinitely for new literature that was published meeting the search criteria above.

Inclusion criteria for this study included patients between the ages of 18 and 65 who sustained an operative tibial plateau fracture and who underwent operative fixation at Loyola University Medical Center. Orthopaedic trauma patients are more likely to be on pre-injury opioids than the general population, which is linked to an extended period of post-operative opioid use (Holman, Stoddard, & Higgins, 2013; Massey, Dodds, Roberts, Servoss, & Blondell, 2006). Other research has pointed to an increase in opioid abuse and dependence among orthopaedic surgical inpatients, associated with considerable post-operative morbidity and mortality and resource utilization, so those taking opioids before surgery were excluded from this study (Menendez, Ring, & Bateman, 2015).

Any who met the following criteria were excluded from analysis: age younger than 18 or older than 65, ASA class 3 or more, known opioid dependence, opioid use greater than 4 weeks (chronic), RA (rheumatoid arthritis), allergies to the study medications, pre-existing lower extremity neurologic deficits or impairments, and any known hepatic/renal impairments that would limit our ability to prescribe opioid pain medications (Table 3.1).

The final patient sample was 211. Dependent variables (outcomes) included opioid use at 3 or 6 months (according to EPIC data mining and chart review showing a current opioid prescription) based on morphine equivalent dose (MED). MED was calculated utilizing the most current accepted method as described in the literature (Bot, Bekkers, Arnstein, Smith, & Ring, 2014; Gammaitoni, Fine, Alvarez, McPherson, & Bergmark, 2003; Patanwala, Duby, Waters, & Erstad, 2007; Svendsen et al., 2011). Patients were categorically assigned by race/ethnicity
(White/Black/Hispanic) as independent variables. Potential confounders included gender (male/female), tibial plateau fracture type (unicondylar/bicondylar), early or unplanned follow-up and/or readmission (no/yes), and smoking status (no/yes).

Table 3.1

List of Number of Participants Excluded by Study Criteria

<table>
<thead>
<tr>
<th>Participants Excluded</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;18 y/o</td>
<td>2</td>
</tr>
<tr>
<td>&gt;65 y/o</td>
<td>38</td>
</tr>
<tr>
<td>Pre-injury opioid use</td>
<td>18</td>
</tr>
<tr>
<td>History of opioid dependence</td>
<td>2</td>
</tr>
<tr>
<td>ASA class ≥ 3</td>
<td>9</td>
</tr>
<tr>
<td>Hepatic or renal impairment</td>
<td>4</td>
</tr>
<tr>
<td>History of lower extremity neurological impairment</td>
<td>4</td>
</tr>
<tr>
<td>Rheumatoid arthritis</td>
<td>2</td>
</tr>
<tr>
<td>No anesthesia record</td>
<td>4</td>
</tr>
<tr>
<td>Received catheter PNB</td>
<td>9</td>
</tr>
<tr>
<td>Race/Ethnicity Not Classified</td>
<td>5</td>
</tr>
<tr>
<td>Received both single shot and catheter PNB</td>
<td>7</td>
</tr>
<tr>
<td>Total Excluded</td>
<td>104</td>
</tr>
</tbody>
</table>

*Note. ASA = American Society of Anesthesiologists, Class 3 = Severe systemic disturbance from any cause or causes; PNB = Peri-operative regional nerve block.*

Data were analyzed using IBM SPSS version 24 (Chicago, IL) statistical software. Bivariate Pearson chi-square analyses were conducted on individual confounders compared to race/ethnicity to determine the effect on long-term opioid use. Logistic regression analyses
were conducted to examine confounding variables and to expand upon results obtained in a prior study. Results were considered significant at \( p < .05 \), with confidence intervals set at 95%.

**Results**

For this study, data were collected from Loyola University Medical Center between the 10 years of 2006-2015, which included 315 operative tibial plateau fractures (unicondylar and bicondylar) that were initially determined to meet inclusion criteria. However, after exclusion criteria were applied, 104 patients were excluded, leaving a final sample size of 211.

Bivariate analyses were conducted to assess for impact on opioid use at 3 and 6 months following operative tibial plateau fracture repair. There was no statistically significant difference in opioid prescription by gender at 3 months \( (\chi^2 = .226, p = .634, df = 1) \) or 6 months \( (\chi^2 = .330, p = .565, df = 1) \). Three months following operative tibial plateau fracture repair, no significant differences were discovered when assessing impact of PNB status \( (\chi^2 = 1.520, p = .218, df = 1) \) or fracture type \( (\chi^2 = .386, p = .535, df = 1) \). At 6 months, findings were similar with no significant difference by PNB \( (\chi^2 = 1.686, p = .194, df = 1) \) or fracture type \( (\chi^2 = 1.323, p = .250, df = 1) \) on opioid prescription following tibial plateau fracture repair. The last bivariate analysis conducted assessed the impact of early follow-up on opioid use at 3 and 6 months following operative tibial plateau repair. Those patients who had some type of early follow-up or readmission continued to be receiving prescription opioids at 3 months at a rate of 72.7% compared to only 35.1% of patients who followed up routinely \( (\chi^2 = 6.331, p = .012, df = 1) \). This difference went away over time and we found no significant differences in the rates of opioid use at 6 months for patients who were routine follow ups versus early follow-up following surgery \( (\chi^2 = .280, p = .597, df = 1) \).
Demographic and anthropometric data were compared to race/ethnicity with no significant differences among gender, smoking status, fracture type, and BMI among different races/ethnicities (Table 3.2).

Table 3.2

Association of Race/Ethnicity With Demographics and Anthropometric Data in Patients Undergoing Tibial Plateau Fracture Repair

<table>
<thead>
<tr>
<th>Race/Ethnicity</th>
<th>N</th>
<th>White</th>
<th>Black</th>
<th>Hispanic</th>
<th>Sig*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>211</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>134</td>
<td>75 (60.0%)</td>
<td>31 (23.1%)</td>
<td>28 (20.9%)</td>
<td>$\chi^2 = 2.159$, $p = .340$</td>
</tr>
<tr>
<td>Female</td>
<td>77</td>
<td>46 (59.7%)</td>
<td>21 (27.3%)</td>
<td>10 (13.0%)</td>
<td></td>
</tr>
<tr>
<td>Smoking Status</td>
<td>211</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>84</td>
<td>48 (57.1%)</td>
<td>26 (31.0%)</td>
<td>10 (11.9%)</td>
<td>$\chi^2 = 5.142$, $p = .076$</td>
</tr>
<tr>
<td>No</td>
<td>127</td>
<td>73 (57.5%)</td>
<td>26 (20.5%)</td>
<td>28 (22.0%)</td>
<td></td>
</tr>
<tr>
<td>Fracture Type</td>
<td>211</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unicondylar</td>
<td>118</td>
<td>67 (56.8%)</td>
<td>29 (24.6%)</td>
<td>22 (18.6%)</td>
<td>$\chi^2 = .075$, $p = .963$</td>
</tr>
<tr>
<td>Bicondylar</td>
<td>93</td>
<td>54 (58.1%)</td>
<td>23 (24.7%)</td>
<td>16 (17.2%)</td>
<td></td>
</tr>
<tr>
<td>Readmission/Early Follow Up</td>
<td>211</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>11</td>
<td>6 (54.5%)</td>
<td>3 (27.3%)</td>
<td>2 (18.2%)</td>
<td>$\chi^2 = .049$, $p = .976$</td>
</tr>
<tr>
<td>No</td>
<td>200</td>
<td>115 (57.5%)</td>
<td>49 (24.5%)</td>
<td>36 (18.0%)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>N</th>
<th>White Average (SD)</th>
<th>Black Average (SD)</th>
<th>Hispanic Average (SD)</th>
<th>Sig*</th>
</tr>
</thead>
</table>

*Note. BMI = Body mass index; SD = Standard deviation.
*p < .05; 95% Confidence Intervals; $\chi^2$ (categorical); ANOVA (continuous).
When assessing opioid use at 3 months after tibial plateau fracture repair, 42.1% of White and Hispanic patients and 23.1% of Black patients still remained on prescription opioids ($\chi^2 = 6.078, p = .048$) (Table 3.3). At 6 months, White patients continued to have higher levels of prescription opioid use at three times the amount for Black patients and more than double the amount for Hispanic patients ($\chi^2 = 6.032, p = .049$) (Table 3.3). Similar rates of opioid prescriptions were found 3 months following tibial plateau fracture repair between smokers and non-smokers, 40.7% and 34.6%, respectively ($\chi^2 = .821, p = .365$) (Table 3.3). Smoking status was also a significant predictor of opioid use at 6 months following surgery, with smokers requiring opioid prescriptions more than double the rate of non-smokers ($\chi^2 = 5.864, p = .015$) (Table 3.3).

### Table 3.3

**Association of Selected Characteristics and Opioid Use at 3 and 6 Months Following Tibial Plateau Fracture Repair**

<table>
<thead>
<tr>
<th></th>
<th>On Opioids 3 Months</th>
<th>On Opioids 6 Months</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>n (%)</td>
</tr>
<tr>
<td><strong>Race/Ethnicity</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>211</td>
<td></td>
</tr>
<tr>
<td></td>
<td>121</td>
<td>51 (42.1%)</td>
</tr>
<tr>
<td>Black</td>
<td>52</td>
<td>12 (23.1%)</td>
</tr>
<tr>
<td>Hispanic</td>
<td>38</td>
<td>16 (42.1%)</td>
</tr>
<tr>
<td><strong>Smoking Status</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>216</td>
<td></td>
</tr>
<tr>
<td></td>
<td>86</td>
<td>35 (40.7%)</td>
</tr>
<tr>
<td>No</td>
<td>130</td>
<td>45 (34.6%)</td>
</tr>
</tbody>
</table>

*Note. PNB = Peri-operative regional nerve block.*

*p < .05; df = 1.
When performing logistic regression to examine the relationship of race/ethnicity on prescription opioid use at 3 and 6 months post-operative while controlling for smoking status, the following results were found (Table 3.4). Black patients were less likely to be on prescription opioids than Whites at both 3 months, \( p = .015, \text{OR} = .396 (.188-.835) \), and 6 months, \( p = .027, \text{OR} = .239 (.067-.852) \) (Table 3.4). Hispanic patients did not differ statistically from White patients in having an opioid prescription at 3 months, \( p = .208, \text{OR} = .438 (.121-1.583) \), or 6 months, \( p = .914, \text{OR} = 1.042 (.495-2.194) \) (Table 3.4). Additionally, at 6 months post-operative from tibial plateau fracture fixation, after controlling for race/ethnicity, smokers were independently more likely to be on prescription opioids than non-smokers, \( p = .013, \text{OR} = 2.874 (1.245-6.635) \) (Table 3.4).

Table 3.4

*Logistic Regression Examining the Association Between Selected Characteristics on Opioid Use 6 Months After Tibial Plateau Fracture Repair*

<table>
<thead>
<tr>
<th></th>
<th>3 Months OR (95% CI)</th>
<th>Sig*</th>
<th>6 Months OR (95% CI)</th>
<th>Sig**</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Race/Ethnicity</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>Ref</td>
<td></td>
<td>Ref</td>
<td></td>
</tr>
<tr>
<td>Black</td>
<td>.239 (.067-.852)</td>
<td>.027</td>
<td>.396 (.188-.835)</td>
<td>.015</td>
</tr>
<tr>
<td>Hispanic</td>
<td>.438 (.121-1.583)</td>
<td>.208</td>
<td>1.042 (.495-2.194)</td>
<td>.914</td>
</tr>
<tr>
<td><strong>Smoking Status</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>Ref</td>
<td></td>
<td>Ref</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>2.874 (1.245-6.635)</td>
<td>.013</td>
<td>1.374 (.765-2.470)</td>
<td>.288</td>
</tr>
</tbody>
</table>

*Note.* OR = Odd’s Ratio.

*p < .05.*
Discussion

An unanticipated outcome was uncovered in Paper One, in that patients undergoing tibial plateau fracture repair were found to have significant differences among long-term opioid prescriptions based on race/ethnicity. The results raised questions of race/ethnicity and whether there were varying patterns of prescribing opioids post-operatively by race/ethnicity of the patient. Specifically, there were significant differences in opioid prescriptions, indicating that White patients were significantly more likely to be on opioid prescriptions at 3 and 6 months when compared to Black patients. The goal of this study was to first identify current knowledge and prevailing theories regarding racial/ethnic impacts on pain control and to determine if our data are consistent with other published literature.

Our results confirmed initial suspicions that race/ethnicity played a significant role in opioid prescription status at 3 and 6 months. In order to isolate this finding, further analyses were conducted that determined that smoking status and unplanned follow-up also played roles in long-term opioid use. After controlling for smoking status, Black patients who underwent operative tibial plateau fracture repair were significantly less likely to be on prescription opioids at both 3 and 6 months after surgery compared to White patients. After controlling for race/ethnicity, smokers who underwent operative tibial plateau fracture repair were not at additional risk of being on opioids than non-smokers at 6 months post-operation. However, at 3 months post-operative from tibial plateau fracture fixation, after controlling for race/ethnicity, smokers were significantly more likely to be on prescription opioids than non-smokers. This is consistent with other published literature suggesting that smoking has a direct association with higher rates of opioid use (Hooten, Shi, Gazelka, & Warner, 2011). However,
controlling for race/ethnicity changed the risk period for smokers from the later period (6 months post-surgery) to the earlier period (3 months) post-operation.

Our research also points to a relatively consistent theme found in other literature demonstrating either a lack of prescribing of pain medication for Black patients or an overprescribing of pain medication for White patients (Hoffman, Trawalter, Axt, & Oliver, 2016). Todd, Deaton, D’Adamo, and Goe (2000) looked specifically at the treatment of extremity fracture pain in the emergency department and found that Whites were treated with analgesics 17% more often than Blacks despite similar pain scores. One survey was conducted in over 19,000 U.S. homes and found that regular opioid use was higher in females and in non-Hispanic Whites (Kelly et al., 2008). Opioid use in the U.S. and abroad is on the rise and warrants continued assessment and research to prevent increased morbidity/mortality (CDC, 2017).

Limiting opioid use based on known risk factors for addiction may also play a role in reducing opioid abuse, which makes studying these risk factors particularly relevant. In addition to race/ethnicity, other literature has demonstrated male smokers are more likely to consume higher quantities of opioids than female smokers; however, evidence of this phenomenon was not seen in this study (Hooten, Townsend, Bruce, Shi, & Warner, 2009).

Strengths of this study included the retrospective style analysis and non-invasiveness of readily available data. Utilizing data from five fellowship-trained orthopaedic trauma surgeons at a single institution over a span of 10 years makes the data more likely to be reliable and allows for more confidence in external validity. The 200 patients studied in this sample had adequate statistical power to detect differences among groups.
Some of the limitations of this study included potential confounders such as socioeconomic status, illicit drug use, unknown amounts of alcohol use, patient compliance with treatment protocols (weight-bearing limitations and willingness to participate fully with physical therapy), injury severity, and other associated trauma, which were factors not controlled for in this research design. Additionally, the chronic long-term pain measure was arbitrarily set at 3 and 6 months, and although prescriptions were written, there is no way for this study to guarantee that each of the patients prescribed opioids was actually taking these medications.

As described in Paper One, something that cannot necessarily be controlled for are the discretionary dosages of opioid pain medication prescribed by attending physicians and orthopaedic surgical residents. At the study institution, for operative tibial plateau fractures, the opioid of choice, hydrocodone/acetaminophen 10/325 mg per oral every 4 to 6 hours, is routinely used for the vast majority of patients, and this is routinely adjusted based on patient needs and medical comorbidities.

As this research found, there is something that leads White patients to be more likely than Black patients to receive opioid prescriptions at 3 and 6 months post-operatively. Certainly, there are levels of variability among prescribers and their willingness to prescribe opioids to patients. The concern is that the patients consistently receiving prescription opioids at 3 and 6 months are White, and less frequently Black. These data do not mirror risk stratification data published by the CDC, which found that Non-Hispanic Whites are more likely to use prescription opioids than Hispanics, but found no significant differences in prescription opioid use between non-Hispanic Whites and non-Hispanic Blacks (CDC, 2017).
It was not the goal of this research to determine the specific reason or determine particular attitudes that may contribute; however, it should be noted that certain theories prevail regarding this topic. Some suggest that there are a priori hypotheses by medical providers and the lay community as well that Black patients have higher pain tolerances (Waytz, Hoffman & Trawalter, 2015). Another possibility is that in fact White patients are more likely to ask for opioid prescriptions or have lower pain thresholds, but the design of this study does not allow this consideration or issues related to racism to be explored. Future studies should examine this further.

Future research could pursue double-blind randomized controlled trials in which only the researchers, and not the orthopaedic surgeons, know which measure is being examined. Perhaps trends could be uncovered that help to illuminate the root cause of White patients being prescribed opioids more often and for longer time periods than other races/ethnicities, particularly given the higher rates of opioid use in this population (Guy, 2017). However, still, there are likely to be a myriad of cultural/social factors and perceptions that cannot necessarily be uncovered, even from a higher-level research design.

As providers who have taken the pledge to do no harm and who want to provide the best possible care, it is of importance that we find factors that may be contributing to the overtreatment or undertreatment of pain in our patients. Each of these pathways is a disservice to the medical community and doesn’t follow evidence-based medicine guidelines. Objective standards of care are ways that we as providers maintain high-level patient care, thus limiting mistakes and avoiding bias in our treatments. This research describes two at-risk patient populations. White patients are at risk of being on opioids for longer periods of time.
and, therefore, have a presumptive higher risk of developing opioid addiction following tibial plateau fracture repair. This should be addressed and prescriber vigilance should be employed to assist in decreasing the epidemic of opioid use that is plaguing our nation and abroad. Black patients are the other at-risk patient population in that they could be in a state of undertreatment and suffering due to lack of adequate pain control; however, they are also less likely to be at risk of long-term opioid use. As these groups were compared to each other, the final answer lies somewhere on a spectrum of balancing the treatment of these two at-risk populations. In conjunction with strong recommendations to curb smoking, these factors can be addressed accordingly and better patient care can occur as a result. Hospitals should evaluate their own prescribing practices to assess certain prescribing trends and evaluate potential anomalies related to those individuals that may be at the highest risk for long-term opioid use following orthopaedic trauma surgery.

References


CHAPTER 4
PNB (PERI-OPERATIVE REGIONAL NERVE BLOCK) USE AND DEDICATED BLOCK TEAMS ASSOCIATION WITH HOSPITAL LENGTH OF STAY AND OTHER FACTORS FOR PATIENTS UNDERGOING OPERATIVE FIXATION OF LOWER EXTREMITY FRACTURES

Background

In those with bone fractures, control of acute pain and discomfort can be accomplished with the use of a regional nerve block (Chelly, Ghisi, & Fanelli, 2010). A peri-operative regional nerve block or PNB is accomplished by injecting local anesthetic (such as bupivacaine, rupivacaine, or lidocaine) adjacent to one or more peripheral nerves supplying the area of the fracture to decrease pain (Fowler, Symons, Sabato, & Myles, 2008). Common peri-neural anesthesia sites for hip and knee surgeries include parasacral, sciatic nerve (posterior or inferior), lumbar plexus blocks (posterior), 3:1 femoral nerve blocks, and iliacus blocks (Nicholls, 2007). Regional nerve blocks may be performed before or after the surgery, and may be administered in a single dose, or left in place via a catheter and dosed repeatedly for 24-72 hours (Nicholls, 2007). As the U.S. focuses on the topic of opioid addiction, investigating alternative pain management options such as the PNB is increasingly relevant (Congress.gov, 2016). Because orthopaedic surgery post-operative management includes pain control, identifying new non-opioid techniques to control or prevent pain should be identified.

Recent research studies on PNB use in orthopaedic surgery have found improvements in functional outcomes (Memtsoudis et al., 2016) and cost effectiveness (Hall-Burton et al., 2016), and have not found increases in rare cases of site infection or nerve injury (Finn et al., 2016;
Kopp et al., 2015; Williams, Ibinson, Gould, & Mangione, 2016) when compared against no PNB. The culture of pain management for patients admitted to hospitals has also been evaluated. Hanna, González-Fernández, Barrett, Williams, and Pronovost (2012) found that in surgical units on the hospital floor at a single institution, the odds of a patient being satisfied were 4.9 times greater if pain control was achieved. As a result of research such as this, hospital initiatives focused on the culture of pain management, such as the introduction of an education pamphlet, which significantly improved self-reported proper opioid disposal rates in post-operative patients in one survey based study of 172 patients (Rose, Sakai, Argue, Froehlich, & Tang, 2016).

In those patients who disregard disposal techniques, they are then afforded the opportunity to use and abuse these leftover opioid medications. As noted by Portenoy (1996), presuming patients do not die as a result of opioid overdose, patients addicted to opioid pain medication will have feelings of opioid dependence and require a gradual weaning process to avoid withdrawal symptoms. Opioid effects on the body have not changed over time, making the previous description of the opioid weaning process still relevant today. During this treatment period and the weaning process, patients have been known to go “doctor shopping” (deceptively utilizing multiple physicians in different regions to obtain multiple prescriptions) in an effort to obtain opioids from multiple healthcare providers (McDonald & Carlson, 2013). Doctor shopping for additional post-operative opioids has been reported to occur more frequently in the orthopaedic trauma population compared to those undergoing elective orthopaedic surgical procedures (Morris, Zumsteg, Archer, Cash, & Mir, 2014). Statewide databases and prescription drug monitoring programs have attempted to curb this process.
(Chakravarthy, Shah, & Lotfipour, 2012). Factors contributing to this phenomenon include the lack of training of medical professionals in prescribing practices, the lack of prescription monitoring schemes to prevent doctor shopping and diversion into illicit channels, insufficient public awareness initiatives, and the large amounts of unused and unneeded prescription drugs in circulation (International Narcotics Control Board [INCB], 2014). These phenomena highlight the need for alternative forms of pain management, such as PNB.

Trend analyses on the use of PNB were conducted on hip and total knee arthroplasties by Cozowicz, Poeran, Zubizarreta, Mazumdar, and Memtsoudis (2016), who found that PNB utilization is increasing over time, whereas the use of neuraxial anaesthesia is experiencing a decrease in utilization. In the field of orthopaedic surgery, researchers have evaluated the frequency of PNB use, and between 2010 and 2013, one group of authors demonstrated a 6.4% or 1.7-fold increase in the use of PNB for total knee arthroplasty or TKA (Fleischut et al., 2015). Between 2010 and 2014, another group of authors compared trends in the use of regional nerve blocks in shoulder arthroscopy patients and found that regional anesthesia alone was more highly associated with board-certified anesthesiologists practicing at university hospitals, older patients, patients with higher American Society of Anesthesiologists (ASA) classification, and shorter procedures (Ende, Gabriel, Vlassakov, Dutton, & Urman, 2016). This study is limited to upper extremity, warranting a need for further exploration in lower extremity orthopaedic surgeries.

The utilization of PNB teams varies by institution, and although some institutions have been utilizing these teams for years, the variability in reliability and efficiency at each institution still remains. From an organizational perspective, the use of PNB offers a service to patients for
decreasing pain, but is also a billable service for the hospital, which increases revenue. At the study institution, difficulties in coordination between the anesthesia teams and orthopaedic surgeons made initial use of PNB limited and cumbersome at best; however, over the last 5 to 10 years, the PNB team has set priorities of trying to improve operating room coordination and efficiency in order to improve patient outcomes and avoid operating room delays as a result of PNB administration (S. Byram, personal communication, February 18, 2017). Because of these efforts, along with perceived improvements in coordination with the PNB team, staff hypothesized that PNB use may have increased in the last 5 years. Additional information regarding the increasing use of dedicated PNB teams at our institution would be helpful in determining not only if a dedicated team can increase the percentage receiving PNB, but also to examine whether PNB was associated with reducing hospital readmission rates following certain orthopaedic procedures that commonly need opioid pain relief. This study was conducted to determine how PNB teams and use of PNB was associated with length of study for such procedures, specifically in those undergoing surgical repair of lower extremity fractures.

To better assess the trends in overall use of regional nerve anesthesia in these fracture patients as well as to assess current trends in the use of PNB, two primary questions were posed: (1) Has the use of PNB for lower extremity fractures increased over the last 10 years during the time dedicated PNB teams were established? (2) Does PNB use for lower extremity fractures decrease hospital length of stay when controlling for other potentially confounding factors?
Method

This study was a retrospective analysis of medical records from a level 1 trauma center, Loyola University Medical Center, from January 1, 2006 through December 31, 2015. This institution sees thousands of operative lower extremity fractures annually. Additionally, the peri-operative regional nerve block team or the “block team” is managed by anesthesia and performs hundreds of peri-operative regional nerve blockade procedures annually.

Inclusion criteria for this study were patients age 18-65 who sustained a lower extremity fracture (to include femur, patella, tibia, fibula, talus, and calcaneus) as indicated by hospital inpatient CPT codes. All patients used for this study included those patients with operative lower extremity fractures who received surgery and for which regional nerve anesthesia is an option. Individuals with the following CPT codes were included: 27236, 27244, 27245, 27248, 28406, 28415, 28420, 28445, 27506, 27507, 27509, 27511, 27513, 27514, 27524, 27535, 27536, 27540, 27758, 27759, 27766, 27784, 27792, 27814, 27822, 27823, 27826, 27827, 27828, 27829, 27832, 64445, 64446, 64447, 64448, and 64450. These patients all underwent operative repair at Loyola University Medical Center. To better improve the number of statistical power of this study, exclusion criteria were limited to American Society of Anesthesiologists (ASA) < 3 (Doyle & Garmon, 2017), hepatic or renal impairment, history of lower extremity neurological impairment, and rheumatoid arthritis. This was built into the study design in order to reduce significant differences among patient severity that might be seen in trauma patients versus elective patients.

The data were encrypted and password protected in the EMR (electronic medical record) at Loyola University Medical Center. Human Subjects Institutional Review Board (HSIRB)
approval was granted and extended by Loyola University Medical Center and Western Michigan University.

In addition to the literature review procedures reported in Chapter 2 of this manuscript, the following literature review was applied to this chapter. Additional search terms were used to update the literature review, which included trend AND nerve block, nerve block AND orthopaedic, nerve block AND fracture AND orthopaedic, nerve block AND fracture AND trend. Weekly alerts for these terms were initiated using Scopus, Web of Science (includes Medline), and PubMed on February 12, 2016 and continued indefinitely. This literature search did not reveal published analyses in the use of PNB rates over time for operative lower extremity fractures.

Based on reported knowledge from the Anesthesia Department chair, although a functioning PNB team has been around for over 10 years, the Block Team has had a much higher rate of use, operational tempo, and higher functionality since January 1, 2010 (S. Edelstein, personal communication, July 3, 2017). As a result of this, PNB team was defined by two time periods: the “No Dedicated PNB Team” time period of January 1, 2006–December 31, 2009 and the “Dedicated PNB Team” time period of January 1, 2010–December 31, 2015. In addition to Dedicated PNB team (yes/no), PNB status (yes/no) was also an independent variable. Dependent variable was hospital length of stay (days). Potential confounders included gender (male/female), age (years), race/ethnicity (White/Black/Other), and insurance type (private, Medicaid, Medicare, Worker’s Compensation, uninsured, or other—charity/grant/institutionally funded). Insurance type variable other was a combination of grant funded, financial assistance, and charity-funded patients to meet sample size requirements.
Hispanic patients, Asian patients, and other unclassified patients were grouped together due to sample size limitations.

Data were analyzed using IBM SPSS version 24 (Chicago, IL) statistical software. The normality of distribution statistics was calculated for continuous variables using Kolmogorov–Smirnov (KS) and Shapiro Wilk tests and by examining skewness and kurtosis. PNB use was assessed longitudinally over 10 years. Following bivariate analyses, linear regression was used to explore confounding with regard to any relationship between hospital length of stay and PNB status. Results were considered significant at $p < .05$, with confidence intervals set at 95%.

Results

There were 2,782 patients who sustained a lower extremity fracture (to include femur, patella, tibia, fibula, talus, and calcaneus) and underwent operative repair at our institution, thus meeting this inclusion criteria. After excluding patients younger than 18 or older than 65, the sample size was again decreased to 2,352. The study was designed to exclude high acuity patients and thus any confounding by acuity and/or elective patient status. After excluding patients with ASA class $\geq$3, hepatic or renal impairment, history of lower extremity neurological impairment, rheumatoid arthritis, no anesthesia record, and utilizing only patients who had surgery by orthopaedic trauma fellowship-trained surgeons, the number of eligible patients and our final sample size was reduced to 1,893.

Identification of the rate of PNB use in lower extremity fracture repair was assessed over 10 years as shown in Figure 4.1. During the No Dedicated Block Team time period of 2006-2009, the average percentage rate of PNB use for lower extremity fracture repair was 8.5%. The Dedicated Block Team time period of 2010-2015 had an average rate of PNB use for
lower extremity fracture repair of 44.0%. This is an average increase of 35.5% in PNB use between the time periods, and there was also a significant increasing trend by year over the entire study period in percentage receiving PNB (Linear by Linear Association test, $\chi^2 = 327.85$, $p < .001, df = 1$) (Figure 4.1). When examined by PNB team periods, the No Dedicated PNB Team used on average 15 PNBs annually, compared to an average 94 for the Dedicated PNB time period. Figure 4.1 is shown below.

![Figure 4.1](image)

*Figure 4.1. Annual rate of PNB (peri-operative regional nerve block) use following lower extremity fracture repair.*

Because the rate of PNB use increased over time at the institution, further analyses were conducted to assess average hospital length of stay between patients undergoing lower extremity fracture repair with PNB and without PNB. The PNB group had a hospital length of stay on average 4.2 days compared to 10.7 days for the no PNB group, $t = 14.364$, $p < .001$, mean difference = 6.5, 95% CI (5.621, 7.398). The yearly results are presented in Figure 4.2.
Figure 4.2. Average hospital length of stay following lower extremity fracture repair according to PNB (peri-operative regional nerve block) status, \( t = 14.364, p < .001 \), mean difference = 6.5, 95% CI (5.621, 7.398).

PNB use went from 9.2% of the patient sample to 44.8% of the patient sample between the two PNB team time periods (\( p < .001 \), \( \chi^2 = 242.047, df = 1 \)). This is demonstrated in Table 4.1.

Table 4.1

<table>
<thead>
<tr>
<th>PNB Status as Determined by Dedicated Block Team Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>PNB Status</td>
</tr>
<tr>
<td>-------------</td>
</tr>
<tr>
<td>Dedicated PNB Team</td>
</tr>
<tr>
<td>Yes</td>
</tr>
</tbody>
</table>

Note. PNB = Peri-operative regional nerve block.
*\( p < .05 \); 95% Confidence Intervals.
Analyses of PNB status by potential confounding factors indicated that gender, insurance type, and race/ethnicity had significantly different rates of PNB use for lower extremity fracture repair (Table 4.2). Age was not associated with PNB status, \( p = .658, t = -.443, \) mean difference = \(-.293, 95\% \text{ CI } (-1.591, 1.005)\) (Table 4.2). It did appear that PNB status was associated with hospital length of stay in the bivariate analysis as well, \( p = <.001, t = 14.364, \) mean difference = \(6.509, 95\% \text{ CI } (5.621, 7.398)\) (Table 4.2).

To determine if there were confounding variables impacting the relationship between hospital length of stay and PNB status, gender, age, race/ethnicity, and insurance type were included in a linear regression model with PNB status. Dummy variables were created and used for race/ethnicity and insurance type. After controlling for these confounders, PNB status continued to significantly reduce hospital length of stay by 6.6 days on average compared to no PNB (Table 4.3). Hospital length of stay for females was on average two days shorter than for males (Table 4.3). Medicaid and charity care/grant funded patients were found to have hospital length of stays on average more than four days longer than patients with private insurance (Table 4.3). Compared to White patients, Black patients’ hospital length of stay was 2.2 days shorter on average and other races/ethnicities averaged 1.7 days shorter than White patients. Age was found to increase hospital length of stay by .09 days per one-year increase in age (Table 4.3).
Table 4.2

*Differences in PNB Status Among Demographics and Other Factors in Patients Undergoing Lower Extremity Fracture Repair*

<table>
<thead>
<tr>
<th></th>
<th>PNB Status</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>PNB n (%)</td>
<td>No PNB n (%)</td>
<td>Sig*</td>
<td></td>
</tr>
<tr>
<td><strong>PNB Status</strong></td>
<td></td>
<td>N</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Gender</strong></td>
<td></td>
<td>1893</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>1184</td>
<td>348 (29.4%)</td>
<td>836 (70.6%)</td>
<td>$\chi^2 = 18.249$</td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>709</td>
<td>276 (38.9%)</td>
<td>433 (61.1%)</td>
<td>$p &lt; .001$</td>
<td></td>
</tr>
<tr>
<td><strong>Race/Ethnicity</strong></td>
<td></td>
<td>1893</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>1193</td>
<td>402 (33.7%)</td>
<td>791 (66.3%)</td>
<td>$\chi^2 = 7.837$</td>
<td></td>
</tr>
<tr>
<td>Black</td>
<td>423</td>
<td>118 (27.9%)</td>
<td>305 (72.1%)</td>
<td>$p = .020$</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>277</td>
<td>104 (37.5%)</td>
<td>173 (62.5%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Insurance Type</strong></td>
<td></td>
<td>1893</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Private</td>
<td>849</td>
<td>276 (32.5%)</td>
<td>573 (67.5%)</td>
<td>$\chi^2 = 24.810$</td>
<td></td>
</tr>
<tr>
<td>Medicaid</td>
<td>354</td>
<td>129 (36.4%)</td>
<td>225 (63.6%)</td>
<td>$p &lt; .001$</td>
<td></td>
</tr>
<tr>
<td>Medicare</td>
<td>143</td>
<td>39 (27.3%)</td>
<td>104 (72.7%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Work Comp</td>
<td>158</td>
<td>70 (44.3%)</td>
<td>88 (55.7%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Uninsured</td>
<td>341</td>
<td>88 (25.8%)</td>
<td>253 (74.2%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>48</td>
<td>22 (45.8%)</td>
<td>26 (54.2%)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>PNB</th>
<th>No PNB</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Average (SD)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Hospital Length of Stay</strong></td>
<td>1893</td>
<td>4.17 (6.831)</td>
<td>10.67 (12.873)</td>
<td>$t = 14.364$</td>
</tr>
<tr>
<td><strong>Age</strong></td>
<td>1893</td>
<td>41.95 (13.287)</td>
<td>41.65 (14.006)</td>
<td>$t = -0.443$</td>
</tr>
</tbody>
</table>

*Note. PNB = Peri-operative regional nerve block; SD = Standard deviation.*

*p < .05; 95% Confidence Intervals; $\chi^2$ (categorical); t test (continuous).*
Table 4.3

Linear Regression Examining the Association Between PNB Status and Other Factors on Hospital Length of Stay

<table>
<thead>
<tr>
<th></th>
<th>β (95% CI)</th>
<th>Sig*</th>
</tr>
</thead>
<tbody>
<tr>
<td>PNB Status</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>Ref</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>−6.588 (−7.661, −5.514)</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>Ref</td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>−1.981 (−3.044, −918)</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>Race/Ethnicity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>Ref</td>
<td></td>
</tr>
<tr>
<td>Black</td>
<td>−2.151 (−3.422, −.880)</td>
<td>.001</td>
</tr>
<tr>
<td>Other</td>
<td>−1.679 (−3.147, −2.10)</td>
<td>.025</td>
</tr>
<tr>
<td>Insurance Type</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Private</td>
<td>Ref</td>
<td></td>
</tr>
<tr>
<td>Medicaid</td>
<td>4.412 (3.007, 5.818)</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>Medicare</td>
<td>.005 (−2.009, 2.019)</td>
<td>.996</td>
</tr>
<tr>
<td>Work Comp</td>
<td>−.003 (−1.899, 1.893)</td>
<td>.997</td>
</tr>
<tr>
<td>Self Pay</td>
<td>−.021 (−1.456, 1.415)</td>
<td>.978</td>
</tr>
<tr>
<td>Other</td>
<td>4.253 (1.014, 7.492)</td>
<td>.010</td>
</tr>
<tr>
<td>Age</td>
<td></td>
<td></td>
</tr>
<tr>
<td>18–65</td>
<td>.087 (.049, .126)</td>
<td>&lt; .001</td>
</tr>
</tbody>
</table>

*Note. β = Unstandardized beta; PNB = Peri-operative regional nerve block. *p < .05.

Discussion

As the opioid epidemic continues to grow in the U.S., so too does the need for alternative solutions to prevent the need for opioid use (Centers for Disease Control and Prevention [CDC], 2017). During the course of this study, questions regarding the utilization of a dedicated PNB team at a single institution were analyzed. Based on results from Paper One
(Chapter 2), it has been determined that, overall, when utilizing PNB for tibial plateau fracture repair, this intervention is decreasing hospital length of stay and post-operative day zero opioid use. To expand on these findings, this study looked at all lower extremity fractures. First, use of PNB before and after the creation of a PNB block team was assessed. Following this, the relationship between hospital length of stay and PNB use was evaluated after controlling for potential confounding variables.

Our results indicate that in fact during the 10-year period assessed, the use of PNB increased from less than 2% in 2006 to over 50% by 2014. This increase was associated with the implementation of a dedicated block team. This may suggest that with more fixed protocols and dedicated staffing of the dedicated PNB team, operating room efficiency has improved and thus provided surgeons with more comfort in allowing for PNB pre- or post-operatively, although they also seem to indicate that it may take time after initial implementation to see the full impact of the intervention. These results suggest there is a value in a dedicated PNB team in increasing the use of PNB for lower extremity fractures.

There are economic impacts associated with these increased length of stays and inadequate pain control, which have surmounted to over $600 billion in treatment and lost productivity costs within hospitals (Simon, 2012). Due to the implementation of a dedicated PNB team, the PNB rates of use increased, and then also PNB use was associated with shorter hospital length of stays after controlling for gender, age, race/ethnicity, and insurance type. In addition to the variables controlled for in the model, the study design had removed many of the high acuity patients, making this a less likely reason for the association between PNB use and length of stay.
Other findings of note in this study include increasing hospital length of stay as a function of increased age, White patients having longer hospital length of stays than other races/ethnicities, Medicaid and grant-funded charity-based patients staying in the hospital more than 4 days longer than privately insured patients, and females having hospital length of stays 2 days shorter than males. Age has been shown to be a significant predictor of increasing hospital length of stay, particularly in the trauma patient (Brotemarkle, Resnick, Michaels, Morton, & Wells, 2015). When assessing 36,153 patients with osteoporotic fractures, one study found that White patients had a shorter length of stay compared to Black and Hispanic patients, that privately insured patients had shorter hospital length of stay compared to the uninsured, and that females continued to have shorter hospital admissions when compared to males (DeShields, Romero, & Cunningham, 2017). These findings are intriguing, and although not the focus of this research, they warrant further exploration in other research studies.

The findings presented here mirror other findings in the literature that show an increasing trend in the use of PNB at other institutions, such as the use of PNB for elective orthopaedic lower extremity procedures such as total knee arthroplasty (TKA) and total hip arthroplasty (THA) (Cozowicz et al., 2016). Other institutions have demonstrated a 13% decrease in unplanned hospital admission rates when PNB was implemented (Williams et al., 2004). When reviewing over 500,000 patients undergoing TKA or THA, Memtsoudis et al. (2013) determined that with the use of PNB, there was a significantly lower incidence of prolonged hospital length of stay, increased cost, and in-hospital complications.

Strengths of this study included utilizing approximately 1,800 patients with retrospective analysis of available data at one institution. Assessing nine fellowship-trained
orthopaedic trauma surgeons along with a dedicated block team that conducts thousands of
PNBs annually provides a certain degree of external validity and provides more confidence in
the results. Ten years of data allowed us to examine changes in PNB use longitudinally.

Some of the limitations of this study included potential confounders that we did not
have access to, including patients’ socioeconomic status (other than insurance type), illicit drug
use, alcohol use, and prior opioid addiction or use. In addition, injury severity and other
associated trauma were factors not controlled for in this study design. Another potential for
confounding is that increased hospital length of stay could be related to delayed admission to
rehabilitation facilities based on insurance status or simply an inability by some patients with
Medicaid or grant/charity-funded care to get rehabilitation facilities to accept them into their
programs. Another consideration is that hospital length of stay at the institution as a whole
may have decreased over this time period for all surgical patients, not just patients undergoing
tibial plateau repair, but these data were not available for comparison. Because there were too
few surgeons that crossed the dedicated block team time period, this variable could not be
analyzed adequately; however, analyses (not shown) conducted found no differences among
surgeons with regard to hospital length of stay when PNB status was also examined. In
addition, there was no specific date to use for the start of the “dedicated block team” time
frame, as the team developed slowly and so was set based on the hiring of acute pain service
staff and implementation of peri-operative block team schedules. One final potential limitation
is that this study expanded PNB use to all lower extremity fractures, whereas certain
procedures have notably longer hospital length of stays than other outpatient procedures. An
example of this would be a simple outpatient lateral malleolus fracture repair versus a bicondylar tibial plateau fracture repair requiring an inpatient admission.

Future research could compare different institutions’ acute pain service programs for orthopaedic surgery outcomes. In doing so, those with dedicated block teams and those without could compare hospital length of stay in relation to the use of PNB for lower extremity fractures. Other research could evaluate the proficiency of the operating room with regard to PNB use on patients undergoing orthopaedic surgery.

As hospitals continue to explore new avenues of approach for treating post-surgical pain, preventing long-term opioid use, and decreasing healthcare costs associated with longer patient length of stays, the use of PNB is a viable addition to the total pain management approach. With the advent of dedicated PNB teams at our institution, PNB use for lower extremity fractures has increased dramatically with an inverse decrease in hospital length of stay for patients receiving PNB. The low risks of peripheral nerve injury and infection, combined with the benefits of decreased day of surgery opioid use and hospital length of stay for orthopaedic trauma patients, make dedicated PNB teams and PNB use a possible significant benefit to the patient and hospital (Kopp et al., 2015; Williams et al., 2016). Models for the implementation of dedicated PNB teams under the supervision of the Acute Pain Service should be explored at all institutions that perform orthopaedic surgeries routinely.

References


Hall-Burton, D. M., Hudson, M. E., Grudziak, J. S., Cunningham, S., Boretsky, K., & Boretsky, K. R. (2016). Regional anesthesia is cost-effective in preventing unanticipated hospital


Opioid use in the United States has become a focus of public health efforts in conjunction with policy interventions designed to curb the current opioid crisis in America and help thwart opioid use as it reaches concerning proportions (Congress.gov, 2016). The focus of this research has been to identify current opioid use and potential practices to decrease post-operative opioid use and hospital admission length in the United States, specifically as it relates to use following orthopaedic trauma surgery. In this subspecialty, we have identified that fractures cause pain and that patients who undergo fracture repair tend to use opioid medication to alleviate this discomfort (Lindenhovious et al., 2009; Luger, Mach, Sevcik, & Mantyh, 2005; Ritsema, Kelen, Pronovost, & Pham, 2007). This is compounded by limitations in the ability of orthopaedic surgeons to treat fracture pain with anti-inflammatory medication due to the known risk of nonunion (Bhandari et al., 2003; Bhattacharyya, Levin, Vrahas, & Solomon, 2005; Giannoudis et al., 2000; Jeffcoach et al., 2014).

To better provide orthopaedic surgeons and anesthesiologists with alternative options for alleviating pain both intra- and post-operatively, this research targets a patient population at risk and explores the use of regional nerve anesthesia. Peri-operative regional nerve blocks (PNB) are designed to target specific nerve pathways supplying the area of pain, where anesthetic medication is delivered to these areas to provide a mode of analgesia that is targeted and sustained (Fowler, Symons, Sabato, & Myles, 2008). Tibial plateau fractures were
identified as an area of research that had not been explored relative to the use of PNB. When surgically repaired, these fractures create hospital admissions of 2 to 7 days (Kayali, Öztürk, Altay, Reisoglu, & Agus, 2008; Rossi, Bonasia, Blonna, Assom, & Castoldi, 2008; Siegler et al., 2011). The primary goals in conducting this research were to establish total short- and long-term prescription of opioid doses, along with a determination of hospital length of stay for patients who received PNB in the repair of tibial plateau fracture repair, and then lower extremity fracture repair compared to those who did not. As a result of the current need to identify alternative pain management techniques in the fracture population, this dissertation addressed specific outcome measures in chapters 2, 3 and 4. The research described was a retrospective analysis of data collected at a single level 1 trauma hospital over 10 years (2006-2015). The following conclusion summarizes the findings in each of the chapters and also provides some insight to the overarching meaning of these results as they pertain to the larger issue of opioid use in the United States.

Chapter 2 of this manuscript assessed patients undergoing operative repair of tibial plateau fractures and compared patients who received single shot PNB to those patients who received no PNB peri-operatively. Outcome measures included total opioids prescribed on the day of surgery and the subsequent 2 days of the hospital admission, opioid prescriptions at 3 and 6 months, hospital length of stay, and unplanned follow-up. These outcome measures were also assessed by possible confounders including demographic data (race/ethnicity, gender, smoking status, age), anthropometric data (body mass index—BMI), and tibial plateau fracture type. Results of Chapter 2 found less total opioid use on the day of surgery and a decrease in hospital length of stay in the single shot PNB group compared to the no PNB group.
Although not of statistical significance, an increase in opioid use in the PNB group compared to the no PNB group was found on post-operative day one, which, when it occurs, is a clinical phenomenon commonly known as “rebound pain.” Long-term opioid prescriptions were associated with race/ethnicity, prompting additional exploration in Chapter 3. Conclusions of these findings indicate that single shot PNB use may be more effective than no PNB for decreasing the day of surgery opioid use and hospital length of stay in patients undergoing tibial plateau fracture repair. One recommendation for hospitals choosing to use this procedure is to anticipate rebound pain and attempt to control for this by prophylactically starting low-dose opioid pain medication prior to the end of the PNB effective time period.

Results of Chapter 2 identified that Black patients were significantly less likely to receive opioid prescriptions compared to White patients at 3 and 6 months following surgical repair of tibial plateau fractures. Although Hispanic patients receive fewer opioid prescriptions than White patients during 3 and 6 months post-operatively, the differences were not statistically significant. The other significant finding was that smokers were significantly more likely to receive opioid pain prescriptions at 6 months post-operatively following tibial plateau fracture repair compared to nonsmokers. When controlling for smoking status, Black patients continued to be less likely to receive opioid prescriptions compared to White patients at 3 and 6 months, following tibial plateau fracture repair. These findings were not expected and the study was not designed specifically to address racial/ethnic differences. Several hypotheses for reasons for this and similar findings can be considered. For instance, there is a question of whether White patients are being overtreated for their pain, or Black patients are being undertreated, or a combination of the above. Identifying risk factors for both over- and
underprescribing of certain races/ethnicities should be heavily evaluated at individual institutions to make objective treatment protocols and avoid potential subversion of stereotypes or assumptions into clinical decision-making. While the focus of this paper was not to identity racism in the medical community, the results do not rule out the possibility and seem to suggest a possible favoritism in prescribing opioids to one race/ethnicity over another. The higher rates of prescription for White patients is consistent with opioid addiction rates in the U.S., since other research has shown opioid to be the highest among non-Hispanic Whites (Kelly et al., 2008; Vaughn, Nelson, Salas-Wright, Qian, & Schootman, 2016). However, the most recent CDC data demonstrate that while non-Hispanic Whites are more likely to be on long-term opioid prescriptions compared to Hispanics, there was no difference between non-Hispanic Whites and Blacks (Centers for Disease Control and Prevention [CDC], 2017). Opioid use in the U.S. and abroad is on the rise and warrants continued assessment and research to prevent increased morbidity/mortality (CDC, 2017). Due to the limitations of a retrospective design, sample size, and somewhat arbitrary measures of opioid prescriptions at 3 and 6 months, the conclusion of this chapter is more of a recommendation to orthopaedic surgeons and hospitals. We recommend that objective prescribing practices are implemented to avoid these potential biases and avoid the perception of favoritism/racism based on our results. Identifying that White patients are perhaps at a higher risk to be on opioid pain medication at 3 and 6 months compared to Black patients at least at one level 1 trauma center following tibial plateau fracture repair warrants a high level of awareness by orthopaedic surgeons and hospitals to identify these patients and objectively make decisions based on the current evidenced-based practice guidelines.
Chapter 4 sought to expand the patient population used in Chapter 2. Chapter 4 expanded the patient population from those undergoing tibial plateau fracture repair to include all surgically repaired lower extremity fractures. In doing so, hospital length of stay based on PNB status and the implementation of a dedicated PNB team were assessed in order to provide better recommendations to hospitals regarding the use of dedicated PNB teams and PNBs in this patient population. Differences in demographic and anthropometric data along with surgeon performing the procedure were also compared.

Results of Chapter 4 found that over the years 2006-2015, the rate of PNB use at one level 1 trauma center increased, and this was directly related to the implementation of a dedicated PNB team. Among patients who underwent operative repair of lower extremity fractures, hospital length of stay was also significantly shorter among those receiving PNB compared to those with no PNB, and this was irrespective of patient demographics and insurance type. These results are useful in identifying the growth and practicality of a commonly used procedure with minimal associated risk, but high reward. The use of the PNB and the implementation of a dedicated PNB team appear beneficial for the patient and the hospital based on our research.

The conclusions of this research have direct applicability to the current opioid prescription problem plaguing the United States. To continue to assist in decreasing opioid prescriptions and opioid prescription doses, to improve patients’ post-operative experience, and to reduce the hospital length of stay associated with patients undergoing fracture repair, PNB should be a high consideration, pending all clinical indications. Decreasing hospital length of stay and day of surgery opioid use can significantly alter the course of a patient’s experience
and potentially improve outcomes associated with these procedures. Hospitals need to make objective recommendations to those prescribing opioids to different races/ethnicities to ensure objective and evidenced-based guidance of prescriptions is used. This paper recommends implementation of a dedicated PNB team in order to increase rates of PNB use. Increasing the use of PNB at hospitals may decrease length of stay in patients undergoing operative fixation of lower extremity fractures as described in Chapter 4, and tibial plateau fractures as described in Chapter 2. A dedicated PNB team may require an initial financial investment by the institution; however, if decreasing the hospital length of stay in these patients, the financial return on investment along with the improvement in patient outcomes makes the investment worthwhile.

The overarching theme of this research is opioid use in the United States and utilizing techniques such as PNB to alleviate this pain and ideally shorten time in the hospital. Opioid use is not limited to orthopaedic surgical patients, but this subpopulation may offer clues to identify alternative treatments in other surgical patients. The results here may also provide a sense of hope that the fight against opioid addiction in America and abroad is not futile. In a combined effort by medical providers and patients, this problem can be targeted and reasonable alternatives offered.

References


Appendix A

Western Michigan University Human Subjects
Institutional Review Board Approval
Date: August 5, 2015

To: Amy Curtis, Principal Investigator
   Joshua Radi, Student Investigator for dissertation
   Frank DiSilvio, Student Investigator

From: Amy Naugle, Ph.D., Chair

Re: HSIRB Project Number 15-07-29

This letter will serve as confirmation that your research project titled “Utility of Regional Nerve Block in Tibia Plateau Fractures: An Assessment of Post-operative Pain and Other Patient Factors” has been approved under the exempt category of review by the Human Subjects Institutional Review Board. The conditions and duration of this approval are specified in the Policies of Western Michigan University. You may now begin to implement the research as described in the application.

Please note: This research may only be conducted exactly in the form it was approved. You must seek specific board approval for any changes in this project (e.g., you must request a post approval change to enroll subjects beyond the number stated in your application under “Number of subjects you want to complete the study”). Failure to obtain approval for changes will result in a protocol deviation. In addition, if there are any unanticipated adverse reactions or unanticipated events associated with the conduct of this research, you should immediately suspend the project and contact the Chair of the HSIRB for consultation.

Reapproval of the project is required if it extends beyond the termination date stated below.

The Board wishes you success in the pursuit of your research goals.

Approval Termination: August 4, 2016
Date: August 4, 2017

To: Amy Curtis, Principal Investigator
    Joshua Radi, Student Investigator for Dissertation

From: Amy Naugle, Ph.D., Chair

Re: HSIRB Project Number 17-08-01

This letter will serve as confirmation that your research project titled “The Impact of Dedicated PNB (Peri-Operative Regional Nerve Block) Teams and Surgeon Preference on PNB use for Patients Undergoing Operative Fixation of Lower Extremity Fractures” has been approved under the exempt category of review by the Human Subjects Institutional Review Board. The conditions and duration of this approval are specified in the Policies of Western Michigan University. You may now begin to implement the research as described in the application.

Please note: This research may only be conducted exactly in the form it was approved. You must seek specific board approval for any changes in this project (e.g., you must request a post approval change to enroll subjects beyond the number stated in your application under “Number of subjects you want to complete the study”). Failure to obtain approval for changes will result in a protocol deviation. In addition, if there are any unanticipated adverse reactions or unanticipated events associated with the conduct of this research, you should immediately suspend the project and contact the Chair of the HSIRB for consultation.

Reapproval of the project is required if it extends beyond the termination date stated below.

The Board wishes you success in the pursuit of your research goals.

Approval Termination: August 3, 2018
Appendix B

Loyola University Institutional Review Board Approval
NOTICE OF FULL APPROVAL OF A RESEARCH PROJECT

Date: 06/10/2015

Investigator: Summers, Mobie

LU Number: 207728

TITLE: Utility of Regional Nerve Block in Tibia Plateau Fractures: An Assessment of Post-operative Pain and Other Patient Factors

ITEMS SUBMITTED FOR REVIEW:

* 06/04/2015 Protocol June 2015

Dear Investigator,

The above-referenced research project was given Full Approval by the Institutional Review Board on 06/10/2015. YOUR PROJECT MAY NOW BEGIN.

Results from the Board Review and required conditions applied to the project can be accessed through the online Research Portal or by clicking this link:

http://portal.luhs.org

The following is for your information and will help you meet local and federal IRB requirements.

1. You must use the final IRB-approved version of the Consent Document. Spelling and grammatical changes may be made as necessary, but any other
changes require prior review and approval.

2. You are required to maintain complete records of this project. Any changes in the protocol and the Consent Document must receive prior IRB approval. Use the online Research Portal's Project Amendment form to report changes. A change to the protocol necessary for the immediate safety and welfare of a research participant may be implemented prior to IRB review and approval.

3. Federal Regulations require that projects undergo periodic review of research activity at least once a year. This review must be substantive. The frequency of review and next scheduled date of periodic review for your project can be found under the "Annual Review" tab in the Research Portal's IRB section. You will receive notification 4-8 weeks prior to the scheduled date of review. At that time, you must provide information regarding the status of the project. If the information is not received, the project will be suspended. It is important that you not let approval lapse.

4. The IRB must be notified any time that the project temporarily or permanently stops enrolling participants along with the reason. Use the online Closure form to submit these notifications.

5. Any notices or advertisements soliciting participation must receive prior IRB approval. Use the online Amendment reporting form.

6. The IRB must be notified PROMPTLY of all serious and any unanticipated adverse events associated with the project (or the device or the drug). This includes any notification received of adverse events occurring at other performance sites. Further guidance on adverse event reporting may be found at the Office for Human Research Protections web site; http://www.hhs.gov/ohrp/policy/AdvEventGuld.htm#Q5

Reportable events include, but are not limited to:
   a) a serious adverse event (including events that produce injury or death, an event leading to hospitalization or lead to prolongation of a current hospital stay);
   b) the enrollment of a patient on a study that is no longer enrolling participants;
   c) pregnancy occurring on the study where the study excludes pregnancy;
   d) any patient reporting a billing problem as a result of project participation;

e) any participant who has voiced a complaint about some aspect of the project
or the consent document;
f) any unanticipated, untoward, or unexpected adverse event not covered
above including
   rare adverse events or adverse events that occur at an unexpected
   rate
g) protocol deviations
h) investigational drug/device brochures, revisions

Adverse Protocol Events are reported through the online Research Portal.

7. The IRB may suspend the project to new participant enrollment or may
suspend the participation of current subjects if there is a perceived safety and/or
regulatory issue.

8. Prospective consent must be obtained from all research participants.

9. The IRB may review your records relating to this project, including
signed consent documents.

10. The Institutional Review Board of Loyola University Medical Center
is appropriately constituted and has been granted Federal Wide Assurance Number
FWH0017487.

11. If you are unsure of your reporting requirements or of what is
expected of you during the conduct of this research, please call the IRB Office (708-
216-4608) or Dr. Kenneth Micetich (708-327-3144).

12. The Loyola Institutional Review Board is appropriately constituted
as stipulated in 45 CFR 46 and is in compliance with Good Clinical Practice Guidelines
insofar as those guidelines are consistent with the U.S. Food and Drug Administration regulations
(21 CFR Parts 50 and 56) and the Department of Health and Human Services regulations (45 CFR 46)
pertaining to the protection of human subjects in research.

Thank you for your cooperation.

Kenneth Craig Micetich, M.D.
Chairman
Institutional Review Board for the Protection of Human Subjects
Loyola University Health Sciences Division

[Signature]

Kenneth Craig Micetich, M.D.
Chairman
Institutional Review Board for the Protection of Human Subjects
Loyola University Health Sciences Division
PROJECT AMENDMENT: NOTICE OF FULL APPROVAL

Investigator: Summers, Hobie

LU Number: 207728

Title: Utility of Regional Nerve Block in Tibia Plateau Fractures: An Assessment of Postoperative Pain and Other Patient Factors

IRB Number: 20772061015

AMENDMENT #1: The purpose of this amendment is to expand the search data from tibial plateau fractures to lower extremity fractures. The importance of this amendment to the study: There is a nationwide trend oriented toward using nerve blocks during operative intervention more frequently. There is still variation amongst institutions in regards to the use of blocks due to issues with anesthestia reliability and efficiency. At Loyola, a team dedicated to performing nerve blocks has been recently implemented. The additional data obtained will allow for assessment about anesthestia team practice, offering a new service, the organization necessary to make blocks easier, available and efficient. This will also allow us to investigate a possible association of blocks with decrease length of hospital stay.

Type of Change: Administrative
Change to Patient Risk: No Change
Change to ICD-10: NO
Inform Past or Current Patients?: NO

Review Date: 04/13/2017
Review Type: Expedited
Action: Full Approval
Comments: Information noted.

DATE OF APPROVAL: 04/13/2017

This Amendment Approval has been granted through an Expedited Review. The Full Board will review the Amendment and/or changes to the Informed Consent Document on 04/19/2017.

If the Board does not reaffirm this expedited decision,
you will be notified by 04/26/2017.

Kenneth Craig Mioshić, M.D.
Chairman
Institutional Review Board for the Protection of Human Subjects
Loyola University Health Sciences/Dan Ryan
From: "Hobie D. Summers" <HSUMMER@lumo.edu>
Subject: PhD
Date: July 20, 2017 at 11:28:39 AM HST
To: JoshRadi <joshradi@gmail.com>

Josh,

Loyola will participate as a site for your research and will create the de-identified data set for you.

Hobie

Hobie Summers, MD
Associate Professor
Chief of Orthopaedic Trauma
Loyola University Medical Center

Confidentiality Notice:
This e-mail, including any attachments is the property of Trinity Health and is intended for the sole use of the intended recipient(s). It may contain information that is privileged and confidential. Any unauthorized review, use, disclosure, or distribution is prohibited. If you are not the intended recipient, please delete this message, and reply to the sender regarding the error in a separate email.