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Continuous Peripheral Nerve Block as an Adjunct to Opioids for Postoperative Pain Management in Foot and Ankle Surgery: A Literature Review

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Abstract: Over the last few decades, there has not only been an increase in opioid prescribing but also an increase in prescription opioid related deaths. In Ohio, the opioid epidemic has played a major role in the recent development of OARRS and physician guidelines for opioid prescribing. Many physicians, including surgeons, have turned to alternative pain management methods, including continuous peripheral nerve block catheters for postoperative pain management. Single peripheral nerve blocks are already commonly utilized for immediate postoperative analgesia. However, limitations to single peripheral nerve block injection include less than 24 hours of analgesia with rebound pain, not always controlled by prescription opioids when the block wears off. The utilization of continuous peripheral nerve block catheters with portable infusion pumps may be beneficial in reducing postoperative pain, and subsequently the amount of postoperative opioid use. Bupivacaine and ropivacaine are the most commonly infused local anesthetics used for peripheral nerve blocks, with a recommended infusion rate for popliteal peripheral nerve catheters as 4-6 mL/h [23]. Peripheral nerve blocks have a low incidence of complications, with similar complication rates seen between single injection and continuous peripheral nerve blocks. Much of the reviewed literature suggests that continuous peripheral nerve blocks allow effective analgesic therapy to be delivered at home, which leads to decreased hospital stays, decreased emergency room visits or hospital readmissions, and decreased reliance on opioids for pain relief, ultimately benefitting the patient.

Key words: Continuous peripheral nerve blocks, continuous popliteal nerve block, peripheral nerve block catheters and popliteal catheter

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There has been a rapid increase in the use of both prescription and non-prescription opioid drugs in the United States since the 1990s.[1] The United States alone consumes 80% of the global opioid supply.[2] Along with the increase in opioid use has come the increase in opioid related deaths. More than 200,000 people have died since 1999 from prescription opioid overdoses and 40% of all opioid overdose deaths today involve prescription opioids [3, 4]. Considerable attention has been placed on the opioid epidemic here in Ohio as well. Since 2007, unintentional drug overdoses have been the leading cause of injury-related death in Ohio [5]. Over 20% of

these deaths have been due to prescription opioid overdoses [5]. Over the past several years, Ohio legislation has not only developed the Ohio Automated Rx Reporting System (OARRS), but has also issued opioid prescribing guidelines for emergency medicine and chronic pain physicians, and most recently surgeons in the outpatient setting. With these changes has come a significant decrease in opioid dispensing. When comparing the number of opioids dispensed in 2011 to 2015, there were 81 million fewer doses dispensed in 2015 [5]. With these changes, physicians and surgeons have turned to alternative pain management strategies in order to continue to care for patient's pain appropriately. One of the strategies being utilized is continuous infusion of local anesthetic through peripheral nerve block catheters for postoperative pain management.

Background

The first continuous peripheral nerve block was used in 1946 by Ansbro, who described a needle attached to an infusion pump that was stabilized through a cork taped to the patient, which he used to assist in prolonging the duration of his surgeries [6]. For many years following Ansbro's case series, continuous nerve blocks were utilized in the hospitals to assist in lengthening procedure times. The infusion pumps at that time were often cumbersome and complex. Continuous peripheral nerve blocks were not employed in the outpatient setting until the 1990s, when Rawal described peripheral nerve blocks through a percutaneous catheter with a portable infusion pump [7]. Today, much of the literature describes peripheral nerve catheters as an adjunct to opioids for management of postoperative analgesia.

As approximately 40% of ambulatory orthopedic surgical patients experience moderate to severe postoperative pain, continuous peripheral nerve blocks can be thought to aid in decreasing the amount of opioids dispensed following foot and ankle procedures [8]. Many surgeons and anesthesiologists already utilize single peripheral nerve blocks to aid in intraoperative anesthesia as well as immediate postoperative analgesia. A single peripheral nerve block injection has been known to provide up to 24 hours of postoperative pain relief [8, 9]. At which time, many patients will rely on oral opioid medications for continued postoperative analgesia. Single injection peripheral nerve block studies have not only demonstrated reduction in overall postoperative pain, but reduction in overall postoperative opioid requirements as well [9, 10].

Despite these promising results, studies have also shown that moderate to severe pain following orthopedic procedures can continue for two to three days postoperatively and patients will often experience increased pain after a peripheral nerve block wears off.[11, 12, 13] Studies have demonstrated that patients who received a single injection peripheral nerve block experience more pain at 12 to 24 hours postoperatively when compared to those who had not received any form of peripheral nerve block pre or postoperatively.[12, 13] The significant increase in pain after the effects of a peripheral nerve block wear off is referred to as rebound pain.[12]

Orthopedic patients presenting to the emergency department or being re-admitted to the hospital for uncontrolled postoperative pain is not uncommon as the intensity of postoperative pain is variable between patient populations. Therefore, management of postoperative pain can be challenging. The utilization of not only peripheral nerve blocks, but also peripheral nerve catheters and continuous infusion pumps may be beneficial in not only reducing the amount of postoperative opioid use, but also reducing the amount of emergency room visits and hospital readmissions for uncontrollable postoperative pain.

Pathophysiology

The propagation of neural transmissions can be divided into negative resting potential (-70 mV), depolarization (+35 mV), and repolarization [14]. When the nerve is in negative resting potential there is an abundance of sodium ions outside of the nerve cell. A neural impulse is generated when the cell reaches voltage threshold by the process of depolarization. Depolarization occurs by a rapid influx of sodium ions entering the cell, which causes the resting potential of the cell to become more positive. Once the cell becomes depolarized, a signal is sent. The cell then returns to negative resting membrane potential by pumping sodium ions out of the cell with the help of the sodium-potassium ATP pump.

Local anesthetics are weak bases and water-soluble, therefore are able to enter the cell by diffusing across the cell membrane.[14, 15] The concept of peripheral nerve blocks involves placing local anesthetic in

proximity to nerve membranes where the anesthetic can diffuse easily into the cell.[16] In the cell, the anesthetic interrupts the signal transmission by interfering with sodium influx, therefore the cell never depolarizes to the appropriate threshold to transmit a signal. This allows the anesthetic to create a reversible blockade and interrupt transmission of autonomic, sensory, and motor signals [16].

Local Anesthetics and Infusion Rates

The most commonly infused local anesthetics include, bupivacaine and ropivacaine [17]. These anesthetics tend to be preferred due to their longer duration of action and favorable sensory-motor block ratio [17]. Bupivacaine is more potent than ropivacaine, though ropivacaine is more motor sparing and less cardiotoxic in comparison [18, 19, 20].

At this time, limited studies are available that specify optimal infusion rates for continuous local anesthetic delivery through a peripheral nerve catheter. Reduction in breakthrough pain and patient's sleep quality are often observed as markers for appropriate rate of infusion in these studies [19, 21, 22]. The current recommendations for infusion rates are based on the location of catheter. The recommended infusion rate for popliteal peripheral nerve catheters is 4-6 mL/h. [23]

Complications

Serious, long-term complications with continuous peripheral nerve blocks are rare and minor, short-term complications are comparable to single injection peripheral nerve blocks.[24] Complications include allergic reaction to anesthetic, vascular damage at injection site, mechanical damage to the nerve at the injection site, hematoma, infection, irritation, or infiltration at catheter site, and early, inadvertent removal of catheter.[25, 26] Most common concerns include nerve damage and catheter site infections. Neuburger et al. reviewed 3,491 peripheral nerve catheter cases from varying anatomic locations and noted 0.2% of patients endured neurologic deficits lasting longer than 6 weeks.[27] A literature review by Capdevila et al. reported up to 3.2% risk of infection with peripheral nerve catheters, with less than 1% relating to peripheral nerve catheters being used in the outpatient setting.[28] In a study by Ding et al., the only complication observed was patient's unintentionally dislodging the catheter prior to completing 48 hour infusion.[29] However, this occurred in 35% of patients, occurring most often when sleeping.[29]

In order to avoid complications, peripheral nerve blocks and catheters are avoided in certain patients. The most common contraindications include patients on anticoagulation therapy as well as those with local infection or hematoma at the site of the proposed block.[30] Patients with hepatic or renal insufficiency are also contraindicated for continuous peripheral nerve block if being discharged home, as there is less supervision and these patients are at higher risk for local anesthetic toxicity.[31] Patient compliance should also be taken into consideration, as not all patients are capable or willing to have a catheter and infusion pump postoperatively.

Comparing Single vs Continuous Peripheral Nerve Blocks

The intraoperative and postoperative analgesia provided by single injection nerve blocks is well known. Many studies have demonstrated the improvement in postoperative pain when a peripheral nerve block has been utilized [32, 33]. However, fewer studies have compared single injection peripheral nerve blocks to continuous peripheral nerve blocks. The most well-known advantage of continuous peripheral nerve blocks is delivering effective pain therapy at home, which can decrease reliance on opioids for analgesia once discharged.[34] Ding et al. looked at rebound pain and opioid use in a prospective randomized trial comparing single versus continuous peripheral nerve blocks in patients undergoing ankle ORIF.[29] Significant decreases in rebound pain was noted in the patient group receiving the continuous peripheral nerve block.[29] However, at 72 hours the two patient groups had equivalent pain scores, which would lead us to believe the continuous nerve blocks provide the most benefit on postoperative days 1 and 2, as single injection peripheral nerve blocks can last up to 24 hours.[29] Ding and colleagues also demonstrated reduction of opioid in the continuous peripheral nerve block group.[29] This was supported by a study by Elliot et al., who compared single injection popliteal blocks to continuous popliteal nerve blocks in major ankle and hindfoot surgeries.[35]

Conclusion

Peripheral nerve blocks can be a safe, reliable, and effective method to managing intraoperative and postoperative pain of foot and ankle surgery. The

literature presented in this review associate peripheral nerve blocks with high patient satisfaction rates and low complication rates. When deciding between single injection versus continuous peripheral nerve blocks, the severity of the surgery should be considered. The specific procedure can help determine the likely postoperative pain and the likely required amount of postoperative analgesia.

Bupivacaine and ropivacaine are the most commonly infused local anesthetics due to their long duration of action and favorable sensory-motor block ratio, with bupivacaine being more potent and ropivacaine having less cardiotoxic.[17] At this time, limited studies are available specifying optimal infusion rates for continuous local anesthetic delivery through a peripheral nerve catheter. Nevertheless, the recommended infusion rate for popliteal peripheral nerve catheters is 4-6 mL/h. [23] Complications seen with peripheral nerve blocks include allergic reaction to anesthetic, vascular damage at injection site, mechanical damage to the nerve at the injection site, hematoma, infection, irritation, or infiltration at catheter site, and early, inadvertent removal of catheter.[25, 26] However, based on the literature included in this review, serious long-term complications are rare, and minor complications have a similar incidence rate to single injection peripheral nerve blocks.

When comparing a single injection of anesthetic to continuous infusion of local anesthetic via a catheter and portable infusion pump, continuous peripheral nerve blocks allow effective analgesic therapy to be delivered at home, which can decrease hospital stays, decrease emergency room visits or hospital readmissions, and decrease reliance on opioids for pain relief. Given the rising costs of health care and the significant increase in not only prescription opioid use, but also prescription opioid overdoses and deaths, it is our duty as physicians and surgeons to find alternative methods to postoperative pain management that will better serve our patients.

However, many aspects of continuous peripheral nerve blocks have not been fully clarified in the literature, including the optimal catheter insertion modality and technique, ideal type of local anesthetic, most optimal local anesthetic infusion rate, and the incidence potential risks. These unknowns open up questions if continuous peripheral nerve blocks are the best method for postoperative analgesia. More prospective research is needed to maximize potential benefits and minimize the potential risks of continuous peripheral nerve blocks.

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