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Development of Guidelines for Early Implementation of Regional Anesthesia in United States Personnel with Peripheral Injuries

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Development of Guidelines for Early Implementation of Regional Anesthesia in United States Personnel with Peripheral Injuries

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Abstract

Dating back to 3200 BC, military personnel routinely experience peripheral extremity wounds during combat. Traditionally, military anesthesia providers utilized general anesthesia and opioids to treat acute pain in the combat setting. Opioids can cause adverse effects such as respiratory depression, delirium, hemodynamic instability, nausea & vomiting, and addiction, which causes delays in care and requires more resources. Regional anesthesia is gaining favor during military operations due to its safety profile and effectiveness in controlling acute pain. Regional anesthesia is safer and more effective than opioids in the trauma/combat setting. Guidelines were provided based on current evidence in the literature and provided to guide anesthesia providers in combat. Implementing a regional training course for military anesthesia providers will instill confidence and provide guidelines for future and current providers in the combat setting. Medical carts in the operating room will reduce the time spent searching for equipment and maintain workflow during combat. Changing the current clinical practice will improve post-surgical recovery and ease of transportation for U.S. personnel serving in the combat setting.

Keywords: regional anesthesia, combat, ultrasound, training course, peripheral extremity wounds

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Introduction

Operation Iraqi Freedom (OIF) and Operation Enduring Freedom (OEF) were 20-year war campaigns that inflicted United States (U.S.) personnel with complex injuries (Scott, 2009). Since the beginning of warfare dating back to 3200 BC, peripheral extremity injuries are common in military operations. As military technology improves, thus do survival rates when injured, producing acute and chronic injuries.

U.S. service members who experience a peripheral extremity (upper or lower) injury inflicted during wartime are routinely given opioids for pain management. Opioid exposure amongst U.S. service members continues to be a growing concern for the Department of Defense (DoD). Long-term exposure to opioids can lead to dependency, increasing immunosuppression, complex regional pain syndrome, and decreased injury recovery time (Stojadinovic et al., 2006). Opioid exposure over the last couple of decades in the U.S. developed into an epidemic, which leads many providers to search for alternative therapies, and military providers are no exception (Gallagher et al., 2019). Regional anesthesia (RA) techniques during combat operations are a feasible alternative to opioid exposure (Jenson, 2006). As a result, a multimodal approach to peripheral extremity injury management becomes more desirable, with RA becoming an integral part of anesthesia management.

Background

Traumas are a constant occurrence in our society; as technologies improve, there is an ever-increasing chance of trauma. The American Association for the Surgery of Trauma (n.d.) explains that trauma in the U.S. accounts for over 150,000 deaths and over three million non-

fatal injuries annually. Applying an appropriate multimodal approach to traumas can decrease recovery time, opioid use, and healthcare costs and improve the patient's quality of life.

Over the last couple of centuries, weapons and tactics continuously improve, causing more complicated injuries to U.S. personnel during combat operations. OEF and OIF left the U.S. with many service members with lasting injuries that require opioid exposure, extended rehabilitation times, and decreased quality of life. As a result, the DoD sees a need to improve recovery from such injuries, reducing the need for rehabilitation time and opioid consumption.

The U.S. actively engages in world conflicts that display increased combat operations and technology that cause service members significant injuries. RA presents one of the significant changes anesthesia providers (i.e., CRNA & anesthesiologists) can implement to improve long-term outcomes for injured service members. Anesthesia providers can improve the quality of life for service members by frequently implementing RA for trauma patients. Trauma patients present with multiple problems, from the initial injury to long-term recovery care. RA will improve all aspects for the trauma patient, from initial pain management to improved recovery times (Mathais et al., 2019). Healthcare organizations worldwide that deal with trauma patients benefit from utilizing this project and can improve patient outcomes for years. Overall, RA is an opportunity to improve care for the trauma patient from many aspects and can improve post-injury recovery.

Early Implementation of RA

Anesthesia providers choose anesthetic plans based on comfortability and efficiency in combat; these may not always be the best choice when treating acute pain for service members. Austere environments in the combat setting cause many limitations for anesthesia providers in treating acute pain in the early phases of surgery (Jenson & Sorensen, 2006). RA provides many

benefits in these settings by optimizing pain control and reducing side effects accompanied by opioids and General Endotracheal Anesthesia (GETA). These side effects include respiratory depression, nausea, vomiting, drowsiness, and addiction. Unfortunately, to decrease these conditions, many therapies needed to treat these conditions are limited in combat operations and can hinder evacuation and post-surgery recovery (Buckenmaier et al., 2003). In addition, reducing symptoms and adequately controlling pain will allow ease of transportation of the service member such that fewer medical personnel are needed to monitor for side effects from opioids and allow active participation from a service member during the transportation process (Buckenmaier et al., 2003, p. 322). Implementing RA early in the acute phase of injury will ensure adequate pain control, reduce the side effects of opioids and GETA, reduce the number of medical personnel to monitor and transport injured service members, and aid recovery from injuries.

Pain Control. One of the most significant challenges posed during the acute phase of injury in combat is adequately assessing and treating pain. Service members typically present with multiple wounds and significant blood loss, resulting in anesthesia providers being reluctant to provide adequate pain control due to concern about side effects that are commonly associated with opioids (respiratory depression, nausea, vomiting, mental confusion, and hypotension) (Clark et al., 2007). Aside from managing short-term side effects for service members, it is essential to reduce chronic opioid use. Reducing chronic opioid use comes from early recognition and RA to manage pain(Jenson & Sorensen, 2005). Providing RA to these service members can provide adequate pain control for surgical procedures and rehabilitation, reducing the number of opioids needed to control acute pain.

Reduced Opioid Side Effects. In healthcare, military and civilian, there is a movement to decrease the use of opioids. The utilization of RA in the perioperative and rehabilitation setting provides many benefits, such as earlier mobilization, reduced adverse physiological effects, and overall satisfaction (Jenson, 2006). Although service members experience positive impacts from opioids, providers must be cautious of side effects that can impede surgical outcomes and rehabilitation duration. Opioid side effects include drowsiness, nausea, vomiting, respiratory depression, hypotension, and addiction (Nambiar et al., 2020). These side effects can easily be thwarted and overcome in a tertiary setting in a metropolis; however, limited supplies and personnel make this task a top concern for providers in the austere environment. RA can reduce these symptoms and allow the soldier to experience adequate pain relief without compromising cognition and the respiratory system.

Ease of Transportation. Among many barriers to service members' surgical care in combat, transportation can present many challenges to medical providers. Providing pain control via opioids contributes to the need for more providers to monitor and care for the service member but also runs the risk of limiting the amount of involvement the service member contributes due to opioid side effects (i.e., drowsiness and delirium) (Buckenmaier et al., 2003). Implementing early RA provides adequate pain control and fewer opioids and allows the service members to participate actively in the evacuation process (Jenson & Sorensen, 2006). Therefore, providing RA early in the acute phase of injury can provide service members with adequate pain control, and transportation takes less time to get to adequate care.

Ultrasound in Combat Operations. Utilizing ultrasound (US) in anesthesia drastically revolutionized how often and safely RA is provided in the clinical setting. Malchow (2009) tells us that the first continuous peripheral nerve block (CPNB) placed in combat was on October 3,

2003, during OIF. Before this historical event, soldiers were treated under GETA and opioids (morphine) regardless of the injury, which left service members to deal with side effects and caused complete incapacitation. Using peripheral nerve stimulators (PNS) under low pressure in stateside hospitals can be accomplished relatively easily, but combat operations can be nearly impossible. US during RA reduces nerve and vascular injuries; anesthesia providers can perform RA procedures quicker and safer by visualizing nerves and vascular structures (Malchow, 2009). Ultimately, US allows anesthesia clinicians to place RA safely and effectively in trauma and military operations.

Ultrasound (US) vs. Peripheral Nerve Stimulators (PNS). Due to medical technology advancements, there have been several changes in the technique for placement of RAs. Prior to the mid-1990s, providers placed peripheral nerve blocks (PNB) with landmark identification and PNS (Orebaugh & Kirkham, 2018). PNS is an additional tool in RA, but the development of US is the gold standard when placing PNBs. During anesthesia studies, identifying landmarks and establishing nerves utilizing PNS are key didactic focuses. However, PNS is more prone to vascular complications (artery punctures and local anesthetic systemic toxicity [LAST]) and is time-consuming compared to the US (Brown, 2008). Combat operations are historically fast-paced and require clinicians to analyze and perform tasks safely and effectively.

Anesthesia providers utilized the US to locate and document nerve plexuses and vascular structures. However, it was fully adopted into practice in the early 2000s due to the limited equipment availability and significant cost (Orebaugh & Kirkham, 2018). Since its inception, the technology dramatically improves RA by providing better image resolution, needle identification, and portability to practitioners utilizing it exclusively to perform PNBs (Orebaugh & Kirkham, 2018). US continues to see an increase in usage in combat since OIF and is a proven

safe and reliable option. Malchow (2009) explains that the benefits of US in combat include providing a complete visualization of the nerve plexuses and vascular structure, decreasing complications, decreasing block setup, and increasing patient comfortability. US continues to see increased usage due to its benefits to service members injured during combat.

US significantly transformed the ability of anesthesia clinicians to perform RA safely and efficiently during combat operations. US was first introduced in 1978 but came into common practice in the 2000s, dramatically increasing the overall success of RA in the hospital setting. RA continuously proves to be a stable application for anesthesia providers since its discovery. US supplies a tremendous impact on this technique and continues to shape RA in routine and emergent surgeries.

Portable Ultrasounds. Portable US is a critical part of providing RA in combat; reduced equipment size, ease of transport, and use of technology will increase acceptance from military officials and anesthesia providers. The introduction of portable US for bedside procedures only added to the convenience and utilization of this technology. Butterfly © (Butterfly Network, 2022) continues to propel the portable US into the future by needing only a probe and a phone to upload an application; anesthesia providers can do numerous studies and procedures such as cardiac exams and RA procedures. Convissar et al. (2021) explain that applying a portable ultrasound (Butterfly IQ+) provides an improved view of the vascular bed, which allows for a convenient, safe, and effective method for providing care at the bedside. Anesthesia providers can conduct numerous procedures safely and effectively at the bedside by adding portable US, such as RA.

Provider Training of RA for Combat Operations

Among the many uncontrollable barriers to performing RA in combat, education and simulation can overcome discomfort with the technique. Croll and Griffith (2016) explain that RA's resistance and comfortability improved with education, training, and persistence. Didactic education includes presenting current and relevant PNB information via the classroom environment, virtual conferences, and computer-based education. In addition, introducing virtual and manikin simulations to a program or organization can improve confidence and competence among anesthesia practitioners (Jaffe et al., 2021). As a result, providers will choose practices they are more comfortable with; by providing education and training, an anesthesia provider will gain the confidence and expertise needed to provide RA to service members in combat.

Didactic Education. RA continuously improves with the utilization of US and identifying nerve plexuses. Providing up-to-date information on current blocks, literature references, local anesthetics, and additional block support (applications) can significantly improve the confidence of the anesthesia provider (Jaffe et al., 2021). Didactic education would provide relevant information to all providers, including ultrasound equipment, optimizing images, interpretation of images, and RA procedures (Narouze et al., 2012). Ensuring all anesthesia providers get the same education across the board will ensure that the application of RA when appropriate in combat is performed confidently and minimizing complications.

Simulation. Opportunities to use education learned and apply them during simulations or clinically will increase clinicians' skills to improve clinicians' preparedness for future combat operations. Chen et al. (2017) tell us that US RA evolved rapidly over the last several decades, and training providers are essential; simulations are the most effective method. Simulations provided virtually or via manikin allow providers to familiarize themselves with proper

techniques and equipment utilization and accurately portray clinical expectations. Simulations after providing didactic education prove to be the most effective training aid to reach experienced and novice providers in the military (Haskins et al., 2021). Making virtual (computer-based) and manikin simulators available to military anesthesia providers will ensure that all components (active duty and reserves) are involved and provide an opportunity to test their knowledge.

Significance Related to Nurse Anesthesia

Healthcare organizations attempt to improve patient outcomes daily, including trauma patients with physical injuries. Physical trauma mortality and morbidity are top priorities, as is improving the quality of life after the initial injury post-trauma (Dhanjal et al., 2019). The DoD implemented the Army Regional Anesthesia & Pain Management Initiative (ARA&PMI) over the last decade to improve service members' treatment and recovery post-injury by utilizing RA (Stojadinovic et al., 2006, p. 331). Trauma centers and rural hospitals gain ways to improve physical trauma patient outcomes from this EBP project through current evidence from the literature and an implementation process plan. In addition, healthcare organizations that encounter trauma patients worldwide benefit from this research and the opportunities RA can provide.

Establishing evidence-based practice (EBP) guidelines that significantly impact opioid consumption and ease of transportation can change how anesthetists care for trauma patients. For example, current studies show that RA provided from the initial injury and throughout the recovery process (when appropriate) improved pain scores and early mobilization (Nambiar et al., 2020, p. 268). The impact of this project does not stop at DoD; it can provide improved quality of life for all trauma patients who suffer from such injuries during any traumatic injury.

PICO(T) Question

The following is the PICO(T) question that was utilized to guide the literature search and development of EBP operational guidelines.

In U.S. Personnel who sustain peripheral extremity injuries during combat (P), how would the development and implementation of early regional anesthesia evidenced-based practice guidelines (I) as compared to traditional practices (C) impact acute post-surgery opioid consumption and ease of transportation (O)?

Project Objectives

Developing EBP guidelines for RA among military medical units allows clinicians to improve early and long-term recovery for patients involved in combat injuries. Stojadinovic et al. (2006) explain that these techniques are not new, but regional techniques are resurgent and provide superior pain control compared to opioid-based anesthesia. Over the last several decades, many combat operations (i.e., OEF & OIF) display a greater need for developing evidence-based guidelines for utilizing RA techniques among service members (Jenson, 2006). Combat injuries plague service members, and the increase in opioid consumption does not solve the problem; RA provides an immense opportunity to improve post-surgery recovery.

This Doctor of Nursing Practice (DNP) project aims to develop guidelines for RA techniques among military clinicians in combat through EBP research. Moran et al. (2019) tell us that objectives help drive the scholarly project and allow for self-assessment for the researcher throughout the process. The objectives this DNP project looks to accomplish are:

- Develop evidence-based practice guidelines for regional techniques during the combat setting.
- Develop a comprehensive plan to implement other recommendations, such as

training and workflow among new and current anesthesia providers, and measure knowledge and technical skills to perform RA techniques.

- Develop a plan to monitor the recommended evidence-based practice guidelines.
- Develop a comprehensive plan to adjust evidence-based practice guidelines if the outcomes are less than expected, such as uncontrolled acute pain requiring increased breakthrough opioid usage and longer transport times.

Developing and implementing EBP guidelines for RA techniques among combat service members will include portable US devices, regional block anatomy, and RA barriers in combat. In addition, developing EBP guidelines for RA amongst military clinicians in the combat setting will require other aspects, such as financial costs, limitations, current provider concerns, and feasibility, will be heavily researched and analyzed.

Literature Search

The author conducted a complete and thorough literature search using vital search terms taken directly from the PICO question. Keywords included *regional anesthesia, trauma, nerve block, and regional block.* The search involved databases of published articles from PubMed and CINAHL Plus. Utilizing these terms provided several articles in CINAHL Plus database, which resulted in 109 articles. The Boolean operator "and" was used to narrow the search results. To narrow the number of articles each term produced, only full-text peer-reviewed articles and articles from 2012-2022 were included, reducing the result to 62 articles. PubMed produced 628 articles. The Boolean operator "and" was used to narrow the search results. To limit the number of articles, only full-text peer-reviewed articles and articles from 2012-2022 were included, which resulted in 41 articles. Of the 150 articles, only 11 were included in the DNP project.

As anticipated, there was a lack of randomized controlled and meta-analysis studies appropriate for this evidence-based project during combat operations. Many relevant articles needed more evidence and were expert opinions, ultimately excluded from the literature search.

Synthesis of Literature

After identifying the need for early implementation of RA in peripheral extremity injuries sustained during combat, the project team searched the literature to show evidence of the problem and its impact on clinical practice. Selected articles during the search highlight multiple aspects of utilizing early RA and its impact in the operative and postoperative setting. Each article selected demonstrates RA's effectiveness at improving recovery time in the postoperative setting.

RA for Combat Injuries

RA is an effective and cost-reduced anesthetic on the civilian side, and many anecdotal articles describe its effectiveness during combat. Nevertheless, no standardized care model for RA is available to combat causalities (Buckenmaier et al., 2003). Li et al. (2021) conducted a meta-analysis of RA compared to systemic analgesia; the article included 31 studies and 2,975 patients. The meta-analysis established that RA produced lower pain scores three months post-surgery than patients receiving systemic analgesics (Li et al., 2021), p. 4). The authors noted that RA decreased opioid consumption and length of stay in PACU and improved positivity on long-term pain, illness, and death (Li et al., 2021, p. 4).

Yeying et al. (2017) conducted a prospective randomized study that included 90 adult patients experiencing multiple rib fractures; 45 patients received Thoracic paravertebral block (TPVB), and 45 patients used intravenous patient-controlled analgesia (IVPCA). The authors stated that both interventions produced comparable pain scores at rest and pre-anesthesia. TPVB

significantly reduced pain scores on days one and two compared to IVPCA (Yeying et al., 2017). Pulmonary function tests and values (PaO2/FiO2, PaO2, FVC, FEV1/FVC) were conducted and monitored; these values showed that the TPVB group showed significantly higher PaO2 and PaO2/FiO2, FVC, and FEV1/FVC compared to the IVPCA group. Yeying et al. (2017) concluded that TPVB provided better analgesia coverage during rest and coughing than IVPCA.

Survivable traumatic combat injuries, such as soft tissue and extremity wounds, continue to make up three-fourths of combat surgical operations; among those injuries, soft tissue and fractures make up two-thirds of surgical interventions (Buckenmaier et al., 2003). Albaqami and Alqarni (2022) conducted a systematic review of ankle blocks and postoperative pain; 11 RCTs were included. The authors concluded that patients that received a RA ankle block experienced significantly lower visual analog scores (VAS) 24 hours postoperatively (Albaqami & Alqarni, 2022, p. 473). Additionally, with the ankle block with another blockade, such as a popliteal block in combination with GETA, patients saw a significant increase in postoperative pain relief, decreased length of stay, and improved post-one-year foot function (Albaqami & Alqarni, 2022, p. 476). During this systemic review RA either alone or combined with other anesthesia techniques, provided significantly lower VAS 24 hours postoperatively for patients.

Providers treating traumatic injuries during combat operations need interventions to treat acute and surgical pain with reliable hemodynamic safety profiles; RA provides a stable hemodynamic profile. Hsu et al. (2019) conducted a systematic review and meta-analysis of femoral nerve blocks (FNB) compared to intravenous anesthesia (IVA) when setting a femur fracture prior to spinal blockade (SB). The article included ten studies with 584 patients; RCTs and observational studies were included. Hsu et al. (2019) concluded that patients who received an FNB prior to fracture setting experienced reduced pain scores, shorter SB times, increased

patient satisfaction, and higher mean arterial pressure scores (MAP) compared to patients who received IVA. Traumatic injuries during combat operations produce long-term illness and chronic pain, and RA effectively decreases acute pain and improves long-term physiologic and psychological outcomes. RA significantly impacts pain scores and hemodynamic stability immediately. Kuchyn and Horoshko (2021) conducted a clinical trial that included 218 patients with gunshot wounds; patients were placed into three groups; group 1 received general anesthesia (53), group 2 received RA (73), and group 3 received RA and sedation (92). The clinical trial focused on which of these anesthetic options during surgery led to a higher rate of patients that experience post-traumatic stress disorder (PTSD). The authors concluded that wounded combatants who sustained a GSW that received GETA were more likely to fail surgical and medical treatment and develop PTSD than the other two groups that received RA (Kuchyn & Horoshko, 2021, p. 5). This study reveals the long-term development of chronic illnesses that are improved by applying RA to surgical and medical interventions.

Ultrasound-Guided Regional Anesthesia (UGRA)

Anesthesia providers utilize three options when utilizing RA, US, and peripheral nerve stimulators (PNS). US reduces local anesthetic volume and vascular puncture and improves the accuracy of nerve blocks. Schnabel et al. (2013) conducted a meta-analysis comparing UGRA outcomes to PNS; this article included 15 RCTs encompassing 977 patients. The authors concluded that UGRA had a higher placement success rate and lower incidences of vascular puncture than PNS alone (Schnabel et al., 2013). McNaught et al. (2011) conducted a double-blinded RCT comparing local anesthetic volume needed for a successful block (patient reporting 0/10 pain, 30mins after block setup). UGRA required 0.9 mL for a successful block compared to PNS, requiring 5.4 mL. Along with less volume needed to perform the block, fewer needle

passes were observed during this study (McNaught et al., 2011, p. 126). Multiple studies alluded to the safety profile and cost-effectiveness of UGRA compared to PNS.

Anesthesia providers during combat require rapid and effective interventions for traumatic injuries, and UGRA provides rapid and effective treatments. UGRA continues to improve peripheral nerve block safety and overall effectiveness in the clinical setting. Büttner et al. (2018) conducted an RCT that included 30 patients to compare peripheral nerve block (PNB) to analgosedation (AS, ketamine, and midazolam) and ease of provider intervention (reduction and splinting of dislocated injury) at the scene of injury, 18 patients received PNB, and 12 patients received AS. Providers who conducted the interventions would rate the process as easy, intermediate, or impossible. The PNB group was rated easy, with 80% of interventions and only 20% impossible, while the AS group was rated easy 22%, intermediate 22%, and impossible 56% (Büttner et al., 2018, p. 6).

Providers could utilize UGRA at the scene of injury with relative ease and significantly reduce pain while maintaining hemodynamic stability compared to using AS. Büttner et al. (2018) discussed the hemodynamics of each group. They found no difference in cardiovascular parameters (HR & BP) but noted lower peripheral oxygen saturations among the AS group, requiring two patients to receive O2 supplementation (p.5). Hemodynamic stability is of great concern to anesthesia providers caring for trauma patients; RA provides a more significant safety profile for trauma patients than systemic analgesia. Additionally, 5.6% of patients who received PNB experienced pain compared to 58.5% of patients that received AS (Büttner et al., 2018). During trauma and combat injuries, anesthesia providers operate under time constraints and limited resources. UGRA can provide opportunities to reduce costs of material and time taken to perform PNB. Ehlers et al. (2017) conducted a cost analysis alongside an RCT, which enrolled

100 patients to receive either UGRA (50 patients) or PNS (48 patients); two patients were excluded from the study. In this study, UGRA took 8.1 minutes and required 28.6 mL of local anesthetic to produce a successful block, compared to PNS, which took 8.6mins and required 42.8 mL of local anesthetic (Ehlers et al., 2017). UGRA was more cost-effective and less time-consuming in 84.7% of cases than PNS (Ehlers et al., 2017). Ultimately, UGRA can provide anesthetists with a speedier and more cost-effective PNB during traumatic combat injuries sustained during combat operations.

Feasibility of RA

Concerns about the applicability of implementing RA at the scene of the injury or immediately upon entering the surgical suite are reasonable. However, the evidence supports the feasibility of an immediate application. Büttner et al. (2018) conducted an RCT that included 30 patients to compare PNB to AS that required medical intervention (reduction and splinting of dislocated injury) in the prehospital setting. This RCT showed that only 5.8% of patients receiving PNB before medical intervention reported pain compared to 58.2% of patients receiving AS reported pain (Büttner et al., 2018). RA demonstrated superior pain control during this study and showed that prehospital medical procedures were more readily performed and feasible with trained providers.

Providing RA during the immediate phase of injury is crucial for controlling the patient's pain, but also for providers who need to perform interventions. McRae et al. (2017) conducted a non-blinded, controlled trial comparing PNB versus standard care of morphine injections among paramedics during the prehospital phase of care to trauma patients. The authors' primary outcome measures determined the patient's verbal numerical pain scale (VPNS, 0 being no pain, 10 being worse pain ever) at baseline, 15 minutes post-intervention, and assessing pain scores on

arrival to the hospital, then again 120 minutes post-intervention. The study revealed that at baseline, each group had similar scores, but 15-minute post scores in the PNB group averaged 3/10 versus the standard care being 7/10. Scores amongst the two groups continued to change as they reached the hospital setting drastically, and 120 minutes post-intervention, the PNB group averaged 1.5 out of 10.

In contrast, the standard of care group was 3.75 out of 10 (McRae et al., 2017). Time on the scene for paramedics that used each treatment intervention was relatively the same, with PNB taking 53 minutes and standard of care taking 48 minutes. Although the PNB intervention took five additional minutes compared to the standard of care group, hemodynamic values were maintained, dramatically decreasing pain scores and treating acute pain. Treating acute pain can be difficult for providers, and RA in this study shows its effectiveness in treating acute pain. Conducting care at the trauma scene must be quick and effective for the injured patient's care and the provider's safety.

The training needed to perform speedy and effective blocks and the feasibility of applying RA in clinical practice takes at least two hours to achieve. Lee et al. (2021) conducted a feasibility study clinical trial that assessed the effectiveness of a two-hour training session for 32 emergency department physicians in PNB and determined pain scores and time to perform the intervention. The study revealed that 22 emergency physicians could complete the nerve block in an average of 15 minutes, and 90% of the nerve blocks were completed in under 30 minutes (Lee et al., 2021, p.4). Pain scores were also tracked during this study and revealed that 94.4% of patients that received a nerve block had a pain score reduction of 3/10, and another 75% of patients had at least a 50% reduction in initial pain scores (Lee et al., 2021). Training to perform PNBs and successfully apply these blocks in the clinical setting was done in as little as two hours

and showed low procedural times and reduced pain scores in the clinical setting; this translation in the trauma and military setting is comparable.

Analyzing current literature showed a need to implement RA early in combat to improve service members' post-surgery recovery. Early implementation of RA controls acute pain more effectively than opioids, reduce side effects associated with opioid consumption, and eases transportation of injured service members. Utilizing ultrasound machines in combat proves more effective and safer than PNS; by involving portable US (Butterfly ©), providers can locate nerve plexuses and vasculature to lessen complications and discomfort. RA provides adequate pain control by reducing opioid consumption in combat settings, enabling injured service members to remain active during recovery operations and lessening the burden of medical personnel to monitor for opioid side effects during combat operations.

Model Used for Project Framework

The model chosen for this DNP project was the Plan-Do-Study-Act (PDSA) model (Appendix F). The PDSA model is widely used to observe change on a small scale and act on learning outcomes to apply on a larger scale (Bernadette & Fineout-Overholt, 2019). Quality improvement (QI) is the focus of this model; utilizing early RA in the combat setting is focused on improving the quality of care that US personnel receive. The model starts by asking three essential questions, "What are we trying to accomplish?" How will we know that a change is an improvement?" What change can we make that will result in improvement?" (Institute for Healthcare Improvement, 2010). Planning this intervention on a small scale, observing the results, and acting on unseen outcomes can help the acceptance of the clinical practice change on a larger scale.

Before starting the PDSA cycle, the project team must answer three essential questions to guide the clinical change. Institute for Healthcare Improvement (2010) explains the three essential questions set aims, establish measures, and select changes to guide the PDSA model. First, the project team aims to improve postoperative recovery among US personnel that receive peripheral extremity injuries during combat. Based on the literature, reduction in breakthrough opioid consumption and ease of transportation are the established measures for this project. Lastly, setting changes to current practice will be essential to train anesthesia providers, ensure equipment and medications are available, and create standard operating procedures (SOP). By establishing the aims, measurements, and changes, the PDSA cycle can begin.

The first step in the PDSA model is to "plan" to enact change in the military; planning is essential. Moran and Conrad (2017) explain that serious planning is essential in starting a DNP project. The Planning phase will begin with designing a training course that will introduce novice and expert anesthesia providers to US probes and RA blocks and provide field simulations to prepare providers for future deployments. Another significant planning aspect for this project will be securing US equipment for providers to implement this change, such as portable ultrasound, local anesthetics, a medical supply cart (to store medications and supplies), and emergency medications. Finally, planning for clinical change will be necessary to accept not only the providers during deployment but also officials throughout the DoD.

The project's "Do" phase will be to implement on a small scale, monitor for unwanted outcomes, and develop SOPs to introduce to the larger military medical community. Institute for Healthcare Improvement (2017) tells us that during this phase of the PDSA model, the provider conducts the test, and data is collected and then analyzed. The starting point will be to train units with a higher incidence of trauma patients and units next in line for deployments. By

implementing on a small scale, the project team will be able to see faster results, mitigate unwanted outcomes, and develop SOPs for other units to follow.

The third phase of the PDSA model is "study," which allows the project team to analyze the data and outcomes before changing clinical practice on a larger scale. Bernadette and Fineout-Overholt (2019) explain that the study phase is after the plan and do phase and provides the team with information to analyze for adjusting future changes. Including units more likely to encounter trauma patients and those up for deployment will ensure a small scale and a greater chance to collect real-time data for analysis. This project's study phase will survey providers and focus on patients' electronic medical record (EMR), acute post-surgery breakthrough opioid consumption, and ease of transportation. Along with provider feedback, the project team will comb through EMR or paper charts to look for hemodynamic numbers and breakthrough opioids used during the postoperative period. This information will provide information on the success of early RA while performing a cost analysis for future changes.

The last phase of the PDSA model is "Act," which involves taking the necessary data analysis and changes and modifying them for continued testing. Chen et al. (2021) explain that once the model achieves its goals without unexpected problems, implementation on a larger scale is necessary to spread across the entire organization. Once the project team declares that the objectives meet without unwanted outcomes, the project can proceed to a larger scale. By understanding the data, the cost, and developing SOPs, the project's application to the entire military medical community will succeed more in the clinical setting.

Guidelines

The traditional practice for military anesthesia providers centers around GETA and systemic opioids. Guidelines developed for this project provide clinicians with recommendations

from the time of notification of peripheral extremity injury, a two-hour timeframe to perform the appropriate block for the specific injury, and equipment necessary to conduct a PNB. Providers assess the PNBs every 15 minutes after placement to determine block success. Providers will document the number of medical personnel required to transport the patient safely after PNB out of the PACU area. These guidelines will be essential for monitoring the outcomes of this scholarly project.

Notification will be given to anesthesia providers when an upper or lower extremity injury occurs. Clinicians will begin obtaining clinical information on the patient, such as the site of injury, allergies, vital signs, and any other pertinent information deemed necessary by the clinician. The anesthesia provider will gather and prepare all equipment before the patient arrives. Equipment necessary to perform PNB is a medical cart, Butterfly © US, sterile gloves, 60 mL syringe, 30 mL vial of ropivacaine, 1% lidocaine with syringe and needle, and a PNB needle and kit. Providers will perform PNBs within two hours of the initial injury.

The upper extremity classifies from the patient's shoulder to their hand. Injuries sustained in this region will receive US-guided Interscalene Blocks (ISB). The lower extremity classifies from the patient's thigh to the foot. Any U.S. personnel that sustains an injury in this area will receive US-guided FNB and Sciatic Nerve Block (SNB). 30 mL of 0.5% ropivacaine will be drawn up and used for both PNBs. Providers will perform PNBs within two hours of the initial injury. A picture of the block (needle, nerve, and vascular structure) should be obtained and maintained in the patient’s medical record; if not, handwritten documentation is acceptable.

Every 15 minutes, PNBs are assessed after placement to determine block success. Successful blocks include if the patient reports zero pain from injury, heaviness, and numbness in the extremity. Anesthesia providers will note all successful blocks and which parameters the

block met. Based on the provider's clinical judgment, an unsuccessful block immediately transitions to the most appropriate anesthetic. The PACU staff will document the number of medical personnel required to safely transport the patient after a successful PNB along with equipment necessary for patient transportation, such as oxygen and an intravenous (IV) pump.

Methods/Implementation

The author designed a plan for future implementation. The development of guidelines is the first step. To implement the project in the future, the team will÷ introduce a two-week RA course and anesthesia workflow improvement.

Early Regional Anesthesia Guidelines: Regional Anesthesia Training

RA training will include a two-week course introducing portable US equipment, regional blocks, complications, checkoffs, and field exercises. A sample training schedule is included in Appendix A and serves as a guide for instructors training clinicians. Two weeks after the initial training, the development of standard operating procedures (SOPs) provides each unit with a guide to transition utilizing RA successfully. Providing didactic information (I-AIM, regional blocks, & complications), checkoff opportunities, and field exercises will instill confidence in military providers utilizing RA techniques.

The training course will begin after the designated travel day and will start with identifying the trainees' expectations and the course's objectives. Lectures begin once course objectives are established, starting with US sciences, portable US, RA anatomy, and complications, followed by upper and lower extremity peripheral blocks. Next, hands-on US training with block models and soldiers begins; established instructions and passing standards for ultrasound checkoffs are provided for trainees.

The test will comprise at least 50 questions and focus on US block identification, scenarios, emergency drug doses, max dosing of local anesthetics, and nerve identification. The test will quantitatively evaluate the students learning throughout the course. If a student fails the first test, administering a second test after remediation will be the final attempt. The student will be released from the course and given additional distance learning materials to review before returning to complete the remainder.

Once the trainees complete the test and successfully demonstrate knowledge of all prior lectures, trainees will move on to familiarization and hands-on portable US training. Instructors will first orient trainees to the US machines and all functions, such as depth, gain, and proper holding of portable machines. Trainees will then be allowed to utilize the block models to gain confidence in portable ultrasound techniques and optimize visualization of nerves and vascular anatomy. Once trainees master the basics of the portable US, they will pair up and take turns visualizing the nerve anatomy and vasculature of training peers. The students will be given ample opportunity during and after class to practice, and instructors will provide feedback during classroom hours. Given one day, Students will conduct a checkoff of each upper and lower extremity block; the instructors will grade students on their ability to find the specific nerve block as a "Go" or a "No-Go," 100% is required to move on to field exercises.

Field scenarios will be conducted during the second week of training and designed to replicate traumas in the combat setting. Students will be allowed to see upper and lower extremity wounds over four days, and with the utilization of manikins and soldiers, role-playing injuries will replicate real-life scenarios. Scenarios will focus on critical injuries such as soft tissue and fractures in recent combat operations. Trainees receive a "Go" or "No-Go" score. Trainees will demonstrate ultrasound and needle techniques on manikins, locate specific nerve

blocks (upper or lower extremity nerve block) and identify nerves and vasculature anatomy on role-playing soldiers. Field training will give trainees confidence in RA techniques and improve deployment workflow.

Anesthesia Workflow

Anesthesia providers will find the medical supply cart inside the OR. It will serve as a central hub for supplies and equipment to mitigate time for implementing RA and maintain workflow for the combat casualty. The medical supply cart must be at least five drawers labeled accordingly. It should be colored or labeled to differentiate between the code, difficult airway, and malignant hyperthermia (MH) carts. The top of the supply cart will always be clear and display local anesthetic max doses, emergency lipids dose, drip settings, and signs and symptoms of local anesthetic systemic toxicity (LAST) (Appendix B).

The top of the medical supply cart will always be clear and display important medication and complication data. The far left will show the max doses of frequently utilized local anesthetics (i.e., ropivacaine, bupivacaine, and lidocaine). The far right will include 20% lipid bolus dosage and drip setting if a patient experiences LAST. The middle of the cart will display the LAST signs and symptoms on the top and emergency drug doses on the bottom. These specific reminders will inform clinicians during emergencies and help mitigate unsatisfactory outcomes during emergencies.

The supply cart will be a minimum of five drawers. Labeled in a specific order that will allow the provider to gain familiarity with the location of supplies to ensure an efficient setup of either a single-shot or continuous RA Drawer, one will be labeled "Local Anesthetics" and house all available anesthetics. Drawer two will be labeled "Syringes & Equipment," this draw will contain single shot and continuous RA kits. Drawer three will be labeled "Sterile Gloves," this

drawer will stock various sizes. Drawer four will be labeled "Emergency Drugs," this draw will include lipids, atropine, epinephrine, and emergency drugs in case of LAST. Drawer five will be labeled "Portable Ultrasounds," this draw will allow clinicians to store unused US, preventing damage or loss of equipment.

The supply sergeant (S4) or whoever is tasked by the commander of that unit (i.e., executive officer (XO) or Headquarters (HHC) Platoon Leader) will monitor resource utilization. Monitoring RA supplies (i.e., local anesthetics, RA kits, and portable ultrasounds) will be done quarterly. The responsible clinician or unit assigned will report all damaged or lost supplies immediately.

The project requires two significant movements, training and operations. Training will be multifaceted and require communication from the schoolhouse and the unit's operation/training officer (S3). Operationally, the commander and the designated movement officer (E5 and above) will move equipment from stateside to outside the contiguous United States (OCONUS). These significant logistical movements will follow traditional military practices and cause no significant workflow or operation tempo disruptions.

Labor impacts will be more costly upfront and should return to baseline or lower as clinicians gain more experience with US and RA techniques. Anesthesia providers with significant RA experience (greater than one year) will lead the initial training as instructors. These training instructors will teach the initial RA course, which will cause higher labor impacts due to the number of clinicians it will pull from active units to train the first round of medical units. Along with clinicians pulled into training as instructors, pulling additional clinicians to train in RA techniques and US techniques will contribute to labor impacts. Once the initial training is complete, labor impacts should return to baseline as seasoned clinicians can be on a

rotational basis, and newer clinicians are provided this education in their initial entry training (IET).

The Information Technology (IT) department (S6) will be involved in the monitoring and measuring aspect of the project. The S6 will need to dedicate a minimum of two soldiers every 90 days to flag medical charts that show clinicians' utilization of RA. This project should minimally impact this department's labor and workflow with every PDSA cycle.

Implementation of this project should slightly impact the clinical workflow. McRae et al. (2017) state that comparing UGRA took 53 minutes to establish pain control versus morphine injections taking 48 minutes. Adding a RA medical supply cart will mitigate the time necessary to look for supplies and equipment. As RA becomes more involved in the clinician's practice, time from the start of the procedure to the successful block should see a return to standard workflow.

The risk of liability for implementing this project is relatively low. The National Defense Authorization Act 2019 (U.S. Congress, 2019) exempts medical providers from malpractice suits taken against them for medical actions during combat. Utilizing US to guide PNB significantly reduces complications by fully visualizing vasculature and other anatomical structures (lungs & nerves) that may cause injury to service members (Brown, 2008). Nambiar et al. (2020) conducted a retrospective study involving 371 patients who received RA and reported no long-term adverse effects.

Timeline

The timeline for the project is two years, from introducing training to completing PDSA cycles (90 days) and analyzing data. The training phase will take one month, two weeks for training (didactic and field exercises), and two weeks to develop standard operating procedures

(SOPs) for units to follow. The PDSA cycle will be conducted in three-month cycles for two years to adjust for unsatisfactory outcomes (uncontrolled pain, nerve injuries, and unstable hemodynamic outcomes) and to make SOPs as effective as possible. During these cycles, project members will conduct After-Action Reviews (AARs) with providers for feedback, review of EMR or paper charting, and assessment of undesirable outcomes (i.e., hemodynamic instability, prolonged time for block success, and PNB complications). Upon completing these PDSA cycles, data reviewed, and adjustments made, the project can be taken military-wide for all anesthesia providers. At the end of the project, data from EMR and clinician feedback will be compiled and summarized.

Budget

This project's budget contains two categories: training and operations. No activity exists for adapting RA into clinical practice in combat, so necessary equipment will be needed to start the project. Operating costs will include all the required equipment (portable US, medications, medical supply carts, RA kits, and emergency drugs) needed for two ORs to function safely and effectively. The budget to get two ORs trained and operational with the necessary equipment will be $23,000.

Training Budget.

The overall training budget for all necessary supplies will be $10,400. The training budget includes portable US (Butterfly ©), RA block models, echogenic needles, a training facility, manikins, and instructors (Appendix C). Pooling resources from supply chains across the military and any new or old facilities for training space can mitigate the training budget: military units and hospital stock echogenic needles and RA kits. Any outdated supplies or unneeded kits could be sent to the training facility to cut costs, along with reusing supplies after completion of

training. Military training courses use manikins; allocating some to this training group will significantly cut costs. Meal plans, hotels, and personnel payments are already budgeted by the DoD each year and will add no additional fees to military units.

Operational Budget.

The overall operational budget for two ORs will be $12,250. The training budget consists of a medical supply cart, portable US (Butterfly ©), local anesthetics (ropivacaine & bupivacaine), RA kits (single shot & continuous), and emergency drugs (lipids 20%) (Appendix B). The budget for operations can be mitigated again by pooling supplies from military depots, unused medical carts, and emergency drugs (epinephrine & atropine) budgeted by military medical units. Specific RA peripheral nerve block supplies such as RA kits and local anesthetics must be purchased dedicated solely to these units.

Outcome Analysis Plan

Analysis of EMR data/paper charts and after-action reviews (AARs) with providers every PDSA cycle will monitor the project's outcomes. Reviewing the medical charts will give valuable information about the ease of transportation (number of providers) and breakthrough opioid use 24 hours after the PNB placement of each patient. PNBs placed within two hours of injury are essential metrics measured; additional blocks outside this timeframe still provide valuable information. Feedback from providers will adjust previous SOPs and improve workflow inside the OR. Adjustments will be made based on outcomes in the medical charts and provider feedback.

Information technology (IT)(S6) will flag the medical charts (EMR or paper charts) that utilize RA, and the project team lead will view the data for acute post-surgery breakthrough opioid use 24 hours after PNB placement and ease of transportation. Viewing the medical data

will provide quantitative data showing how effective this project's implementation is in providing adequate postoperative analgesia. Breakthrough opioid use within the first 24 hours will be a crucial focus of the outcomes analysis and providing feedback on the effectiveness of early RA and patient pain control. Project members will evaluate the number of providers and additional equipment needed to transport patients after successful PNB placement; patients requiring two or fewer transport providers will be considered successful. Medical charts will provide the quantitative data needed to adjust and sustain current practices before implementing across all military hospitals.

The project team will focus on PNBs placed within two hours of injury. PNBs placed during the appropriate timeframe will drive adjustments of outcomes. Project team members will monitor any PNB placed outside the timeframe for future guideline adjustments and research projects. Each PNB within or outside the two-hour timeframe provides valuable information for anesthesia providers providing RA to patients in the combat setting.

After-action reviews are commonly used in the US Army to analyze current practices for sustainment and adjustments directly after an event. Allowing individuals involved to provide accurate and timely feedback. Provider feedback via AARs adjusts and sustains current practices in the implementation plan. However, it will also allow the RA training course to adjust based on provider experience. Information gathered in each PDSA cycle will allow the project lead to adjust or sustain current practices based on provider feedback.

Adjustment of the Guideline

A PDSA cycle occurs every 90 days to review the data and perform AARs with military anesthesia providers to assess for unsatisfactory outcomes. Patient data will be monitored in the medical charts (EMR/paper chart) to ensure that nerve injuries, hemodynamics, and pain scores

adequately reflect expected outcomes. Project members will monitor the time until successful block establishment to evaluate the efficiency and ensure minimal delay in operations. UGRA is a safe technique, and the team lead will evaluate outcomes to ensure nerve injuries and vascular injuries are being prevented.

Medical charts will be reviewed by the project team leader every PDSA cycle to evaluate adverse outcomes (nerve injury, unstable hemodynamics, and unsuccessful PNB) from RA. An increase in nerve injuries will require a thorough AAR follow-up with clinicians to determine the need for more formal training or including a nerve stimulator with PNB. Project members will assess hemodynamic stability in the medical charts and practices of sedation before PNB; sedatives may need to be adjusted (Midazolam to ketamine) or reduce the amount of local anesthetic used in blocks. The project team leader will also monitor unsuccessful blocks. The AARs will guide the need for practice change, including peripheral nerve stimulators with UGRA or adjusting the dosage of local anesthetics.

The literature provides evidence of UGRA's success and safety profile. However, the project team members will still need to monitor it to ensure that no adjustments are needed or that evidence is working in combat. UGRA enables the anesthesia provider to see the nerve, vascular anatomy, and vital anatomical landmarks (lungs and bones), but issues can still arise. If data points show an increase in accidental injuries, a nerve stimulator can be added to ensure providers see appropriate muscle twitches before depositing local anesthetic into the intended nerve.

Once all data points are assessed and adjusted, the project team leader should continue the PDSA cycle to evaluate unsatisfactory outcomes continuously. As adjustments are needed,

EMR data will provide quantitative data, and AARs will provide insight from anesthesia providers as the barriers to successful implementation.

Disseminate the Plan

Upon adjusting and completing all critical data points, a poster board presentation to Otterbein DNP staff and peers will encompass project details. The purpose of the poster board will be to cover important topics of the project and answer questions. Secondly, once the effective implementation of the project and all relevant data are processed, the results will be disseminated to key stakeholders in the military via PowerPoint. The information provided to the critical stakeholders in the military will determine when the project impacts military units and hospitals across the DoD.

Conclusion

Traditionally, U.S. personnel who sustain peripheral extremity injuries during combat operations receive GETA and opioids. These patients require more breakthrough opioids in the acute surgical recovery phase and more medical staff to monitor these patients in a resource-limited environment. RA provides a way for clinicians to manage and treat acute pain while lessening the number of breakthrough opioids and requiring fewer medical staff to monitor and transport due to reducing the side effects of opioids (delirium, nausea and vomiting, and respiratory failure). The DoD recognizes the need to find alternative pain management in combat to reduce the chronic need for opioids and better utilize scarce resources. RA provides an opportunity for clinicians to improve the quality-of-life post-surgical intervention for U.S. personnel.

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Appendix A

Sample Training Schedule

Week One	
Sunday	In-processing & Orientation
Monday	Code of conduct, course objectives, lectures: Ultrasound science, portable ultrasounds, regional anesthesia anatomy, lunch, upper, and lower peripheral nerve blocks
Tuesday	Ultrasound hands-on training with block models, lunch, ultrasounds with soldiers, introduce ultrasound checkoffs and expectations.
Wednesday	Test day (50-question test)
Thursday	Practice ultrasound, lunch, practice ultrasound
Friday	Ultrasound checkoffs, lunch, Warning order (WARNO) for field exercise: Operation Blockade
Saturday	Operation orders, pack for the field, pre-combat checks (PCCs), and pre-combat inspections (PCIs).

Week Two	
Sunday	Movement to field
Monday	Scenario, upper extremity wounds: Interscalene, Supraclavicular, & Axillary blocks
Tuesday	Scenarios, Lower Extremity Wounds: Abductor Canal, IPACK, Ankle block, Femoral Nerve Block
Wednesday	Scenarios, a combination of extremity wounds
Thursday	Scenarios continued, WARNO for movement back to the garrison—final grades.
Friday	Movement to the garrison, finalize paperwork and conduct after-action reviews (AARs).
Saturday	Graduation and travel to home station

Appendix B

Top Medical Cart Labels

Local Anesthetic Max Dosage (Without Epi/With Epi)	
Ropivacaine	3 mg/kg (max 225 mg)/4 mg/kg(max 225 mg)
Bupivacaine	2.5 mg/kg (max 175 mg)/3 mg/kg (max 225 mg)
Lidocaine	4.5 mg/kg (max 300 mg)/7 mg/kg (max 500 mg)

LAST Signs & Symptoms	
Numbness of tongue	Lightheadedness
Visual and auditory disturbances	Muscular twitching
Unconsciousness	Convulsions
Coma	Respiratory/Cardiac arrest

Emergency Drugs & Recommend Dosage	
Epinephrine	10-100 mcg
Atropine	300-600 mcg
Suxamethonium	40-100 mg
Ephedrine	5-15 mg
Phenylephrine	100-200 mcg
Glycopyrrolate	200-400 mcg

Lipid Emulsion Therapy
Bolus 1.5 mg/kg
Infusion 0.25 mL/kg/min
Assess
Cardiovascular instability (repeat bolus)/ Hypotension (double infusion rate 0.5 mL/kg/min)

Order follows from left to right on top of the medical cart.

Appendix C

Training & Operational Budget

ITEMS	TRAINING	ITEMS	OPERATION
Butterfly	3 ($7,200)	Butterfly	3 ($7,200)
Regional Anesthesia Model	3 ($2,176)	Medical Cart	2 ($1,440)
Echogenic Needles (25/box)	2 ($1,020)	Local Anesthetics	
		Ropivacaine (0.2%,500 mL)	25 vials ($353.75)
		Bupivacaine (0.25%, 750 mL)	25 vials ($65.08)
Manikin	3 ($0)	Regional Anesthesia Kits	
		Single shot (25/box)	4 boxes ($2,040)
		Continuous (10/case)	2 boxes ($698)
Meals	1 ($0)	Emergency Drugs	
		Lipids 20% (2500 mL)	10 bags ($506)
Personnel Payment			
Instructors	5 ($0)		
Training Space			
Classroom	1 ($0)		
Field	1 ($0)		
Total	**$10,400**	**Total:**	**$12,250**

Appendix D

Guidelines

OhioHealth	GUIDELINE DRAFT
TITLE: Evidence-Based Practice Guidelines for Implementing Early Regional Anesthesia for US Personnel with Peripheral Injuries	**NUMBER:**
ISSUE DATE:	**EFFECTIVE DATE:**
DEVELOPED / REVISED BY: Matthew R. Baker	
REVIEWED BY: Department of Anesthesiology Surgery/Anesthesia CPIT	**DATE REVIEWED:**
APPROVED BY:	

SCOPE - This guideline is in effect for the following Medical Unit X: Forward Sustainment Hospital AAA

STATEMENT OF PURPOSE:
This guideline aims to provide evidence-based practice guidelines and recommendations regarding upper & lower extremity injuries of U.S. Personnel.

DEFINITIONS:

- **U.S. Personnel:** Service members and civilian contractors
- **Operational Setting:** Field Training or deployment setting
- **Upper Extremity:** Shoulder to the hand
- **Lower Extremity:** Thigh to the foot.
- **Peripheral Nerve Blocks (PNB):** Upper & lower extremity nerve blocks
- **Local Anesthetic Systemic Toxicity (LAST):** Severe complication from accidental vascular injection or overdosing local anesthetic in PNB.

POLICY: This guideline applies to anesthesia practitioners who provide regional anesthesia or may be used to assist those practitioners providing regional anesthesia to U.S. Personnel in an operating room. This guideline intends to assist providers that are providing regional anesthesia. This guideline DOES NOT supersede the anesthesia provider's clinical judgment when a patient's safety is a risk when performing a PNB (local anesthetic allergy or provider safety)
Guideline:

1. **Notification of Injury:**
    1. The anesthesia provider is notified of the injury via radio or verbally by the OR staff. The provider will confirm the injury site (upper or lower extremity) and determine the feasibility and safety of placing the PNB before surgical intervention.
    2. Providers will ensure all equipment needed for PNB is ready before patient arrival.
        1. Equipment needed:

1. PNB medical cart
2. Butterfly © US
3. 30 mL vial of 0.5% Ropivacaine
4. 60 mL syringe
5. PNB needle and kit
6. Sterile gloves
7. Lidocaine 1% w/syringe and needle.

3. Perform PNBs within two hours of injury.

2. **Upper Extremity Injury:**
    1. Upper extremity injuries are any injury sustained from the shoulder to the hand of the patient.
    2. **Interscalene Block (ISB):**
        1. Performed on all upper extremity injuries.
        2. Perform block within the first two hours of injury.
        3. Utilize ultrasound (US) for PNB placement.
    3. **Medications used:**
        1. 30 mL of 0.5% Ropivacaine.
        2. Providers may use versed (2 mg) and fentanyl (50-100 mcg) for moderate sedation during PNB placement.
    4. **Recording:**
        1. A picture will be obtained and attached to the patient's chart.
        2. Needle, nerve, and vascular structures should be visible.
        3. If a picture is not obtainable, handwritten documentation will be acceptable.
3. **Lower Extremity Injury:**
    1. A lower extremity injury is any injury sustained from the thigh to the foot.
    2. **Femoral Nerve Block (FNB) & Sciatic Nerve Block (SNB):**
        1. Performed on all lower extremity injuries.
        2. Perform block within the first two hours of injury.
        3. Utilize US for PNB placement.
4. **Medications used:**
    1. 30 mL of 0.5% ropivacaine.
    2. Providers may use versed (2 mg) and fentanyl (50-100 mcg) for moderate sedation during PNB placement.
5. **Recording:**
    1. A picture will be obtained and attached to the patient's chart.
    2. Needle, nerve, and vascular structures should be visible.
    3. If a picture is not obtainable, handwritten documentation will be acceptable.
6. **Block Assessment:**
    1. Assess all upper & lower extremity blocks every 15 minutes after placement to determine the success of the block.
    2. Providers will assess the extremity for pain, heaviness, or numbness.
    3. Unsuccessful blocks should be transitioned to the most appropriate anesthetic by the anesthesia provider.

7. **Transportation:**
    1. Document the number of providers required to safely transport patients out of the PACU area**.**
    2. Document additional equipment needed to transport examples include, but are not limited to:
        1. Oxygen
        2. Intravenous pump (IV)

Appendix E

Literature Search Table

Regional Anesthesia for Traumatic Injuries									
Citation (Author, Year, Title, etc.)	Conceptual Framework (Theoretical basis for study)	Design/Methods	Sample/Setting (Number, Characteristics, Exclusions, Criteria, Attrition)	Major Variables; Definitions (Independent Variables; Dependent Variables)	Outcome Measurement (What scales used-reliability information-alphas	Data Analysis (What stats were used?)	Findings (Statistical findings or qualitative findings)	Level of Evidence Level =	Quality of evidence Strength Limits Risks Feasibility
Albaqami, M. S., & Alqarni, A. A. (2022). Efficacy of regional anesthesia using ankle block in ankle and foot surgeries: A systematic review. *European Review for Medical and Pharmacological Sciences*, *26*(2), 471–484. https://doi.org/10.26355/eurrev_202201_27872	N/A	Systematic Review and Meta-Analyses from Jan 2005 till April 2021	All studies included in the study met the PICO: patients who underwent foot and ankle surgery, ankle nerve block used, single injection, VAS; 11 studies were included.	Dependent Variables: Anatomical Landmark Guided (ALG)/ Ultrasound-guided ankle blocks Independent Variables: Patient outcomes	Visual Analog Scores and Patient Satisfaction Scale	The study looked at regional approaches to ankle blocks, VAS Pain scores, a combination of anesthetic techniques, Patient Satisfaction Scores, and single long-acting local anesthetics.	Regional anesthesia is a highly effective method for controlling postoperative pain in the ankle in foot surgeries.	I	The authors included six RCTs and nine prospective comparative studies, suggesting strong evidence. The study only included 11 studies, making it a relatively small sample size.
Hsu, Y.-P., Hsu, C.-W., Chu, K., Huang, W.-C., Bai, C.-H., Huang, C.-J., Cheng, S.-W., Chen, J.-H., & Chen, C. (2019). Efficacy and safety of femoral nerve block for the positioning of femur fracture	N/A	Systemic Review and Meta-Analyses up to January 2018	All studies compared FNB versus IVA during positioning during a femur fracture. 584 patients were included in	Independent Variables: FNB & IVA Dependent Variables: Pain scores during positioning after	Visual Analog Scores, Patient and Provider interviews	The study compared pain scores 30 mins after fracture positioning when using an FNB versus	FNB pain scores were significantly lower than IVA during positioning 30mins before the	I	Ten RCT studies were included, which included 584 patients.

patients before a spinal block – a systematic review and meta-analysis. *PLOS ONE*, *14*(5), e0216337. https://doi.org/10.1371/journal.pone.0216337			over ten studies.	30mins of nerve block, Secondary: time until block, additional analgesia, provider satisfaction, hemodynamics, and positioning quality.		IVA, along with secondary outcomes such as hemodynamics, provider satisfaction, patient acceptance, and additional analgesia.	nerve block.		
Kuchyn, I., & Horoshko, V. (2021). Predictors of treatment failure among patients with gunshot wounds and post-traumatic stress disorder. *BMC Anesthesiology*, *21*(1), 1–6. https://doi.org/10.1186/s12871-021-01482-8	N/A	Clinical Trial	218 patients were enrolled in the trial. Each of the participants sustained GSW during combat operations.	Independent Variables: Group 1: General Anesthesia only Group 2: Patients received peripheral nerve blocks. Group 3: Regional Anesthesia with sedation Dependent Variables. GSW victims	Scales used during this study were Mississippi Scale for Combat-Related PTSD (M-PTSD), ASA classifications, pain intensity, Visual Analogue Scale (VAS), and Douleur Neuropathique 4 questions (DN4)	Stats used during this study was 17 characteristics of PTSD treatment failure predictors: anesthesia type, BMI, Height, weight, ASA, age, operation and anesthesia duration, systolic and diastolic pressures, heart rate, and pre- and post-pain scores. VAS scores were used, along with re and post DN4 & M-PTSD.	General anesthesia, compared to regional anesthesia, produced higher postoperative pain intensity, which show higher rates of PTSD treatment failure	III	218 patients were enrolled in the study

Li, Q., Zhang, X., Tao, Y., Xu, Y., Peng, C., & Chen, L. (2021). Regional anesthetics versus analgesia for stopping the persistent post-surgical pain: A meta-analysis. *International Journal of Clinical Practice*, *75*(8), 1–9. https://doi.org/10.1111/ijcp.14159	N/A	Meta-analysis	A systematic literature search was conducted, which included 31 studies. 2,975 subjects were included. Two groups were included, the regional anesthesia group and the conventional anesthesia group	Independent Variables: Individuals (adults and children) that underwent surgery. Dependent Variables: Regional anesthesia and systemic analgesia. Exclusion Criteria: Studies that only compare regional anesthesia, local anesthetics that were not used for analgesia, and studies focused on the effect of timing.	The study looked to evaluate postoperative pain three months post-surgery.		This study showed that regional anesthesia subjects reported persistently lower pain three months post-surgery. Also, the study noted that regional anesthesia reported decreased post-surgical opioid needs, length of stay, and impact positively on long-term results on persistent post-surgical pain, illness, and death.	I	31 studies were included in this meta-analysis, 2,975 patients were included, 1471 used regional anesthesia, and 1319 used conventional anesthesia
Yeying, G., Liyong, Y., Yuebo, C., Yu, Z., Guangao, Y., Weihu, M., & Liujun, Z. (2017). Thoracic paravertebral block versus intravenous patient-controlled analgesia for pain treatment in patients with multiple rib	N/A	Prospective Randomized Study	The randomized study included 90 patients with unilateral multiple rib fractures (MWF) and compared the two groups	Independent Variable: Patients with unilateral MRFs. Dependent Variables: Thoracic paravertebral block	This study compared VAS, blood gas analysis, and bedside spirometry 60mins post-intervention, one day, and three days.	Stats used to compare the two groups were VAS (0 to 10), Blood gas (PaO2), PaCO2, PaO2/FiO2, and A-a	This study showed that the TPVB group had decreased VAS at rest, and with coughing,	II	90 patients were included in this study, 45 patients received thoracic paravertebral

fractures. *Journal of International Medical Research*, *45*(6), 2085–2091. https://doi.org/10.1177/0300060517710068			with PNB and Intravenous patient-controlled analgesia (IVPCA) and assessing VAS, blood gas, and bedside spirometry	(TPVB) and IVPCA		gradient. Bedside spirometry to assess Forced vital capacity (FVC), Expiratory volume (EV), FEV1/FVC, and peak expiratory flow rates	blood gas analysis showed PaO2 and PaO2/FiO2 were increased and a decreased A-a gradient compared to IVPCA. TVPB group showed better bedside pulmonary spirometry		block, and 45 patients received intravenous controlled analgesia

Ultrasound-Guided Regional Anesthesia (UGRA)									
Citation (Author, Year, Title, etc.)	Conceptual Framework (Theoretical basis for study)	Design/Methods	Sample/Setting (Number, Characteristics, Exclusions, Criteria, Attrition)	Major Variables; Definitions (Independent Variables; Dependent Variables)	Outcome Measurement (What scales used-reliability information-alphas	Data Analysis (What stats were used?)	Findings (Statistical findings or qualitative findings)	Level of Evidence Level =	Quality of evidence Strength Limits Risks Feasibility

Büttner, B., Mansur, A., Kalmbach, M., Hinz, J., Volk, T., Szalai, K., Roessler, M., & Bergmann, I. (2018). Prehospital ultrasound-guided nerve blocks improve reduction-feasibility of dislocated extremity injuries compared to systemic analgesia. a randomized controlled trial. *PLOS ONE*, *13*(7), e0199776. https://doi.org/10.1371/journal.pone.0199776	N/A	Randomized Controlled Trail	Thirty patients were included in the RCT; 18 received PNB, and 12 received analgesia. Patients 18 years and older were included in the study. Inclusion criteria were isolated injuries of extremity causing pain and requiring prehospital treatment. Exclusion criteria were preexisting nerve damage of extremity or local anesthetic allergy	Independent Variables: Extremity injuries requiring prehospital intervention Dependent Variables: The PNB group and Analgesia group received ketamine, fentanyl, and midazolam	Patient characteristics (injury and location), Pain scores were recorded via VAS. The onset of PNB and AS were recorded, If the intervention were required, providers would rate the techniques as easy, intermediate, or impossible. Patients were reviewed by a blinded study doctor for pain at the scene, after the intervention, prehospital treatment, pain the following day, and if they would recommend the technique.	The primary outcome was the presence of pain during the prehospital intervention. The secondary outcome was the feasibility of reduction associated with pain scores at the scene, immediately after the intervention, and the rest of the whole day of the accident, the first and second days.	Patients with PNB exhibited more stable blood pressure than the AS group. Pronounced hypoxemia was noted in two AS patients and none via the PNB group. Providers rated 80% of patients who received PNB easy to perform reduction and only 20% as impossible, compared to the AS group, which rated 22.2% easy, 22.2% as intermediate, and 55.6% as impossible to reduce.	II	30 patients were included in this RCT. 18 patients were placed into the Ultrasound Guided PNB, and 12 were placed into the Angloseda tion group; the strength of this study includes it being a higher level of evidence and an RCT. The weakness is the small sample size.

Ehlers, L., Jensen, J., & Bendtsen, T. (2012). Cost-effectiveness of ultrasound vs nerve stimulation guidance for continuous sciatic nerve block †. *British Journal of Anaesthesia*, *109*(5), 804–808. https://doi.org/10.1093/bja/aes259	N/A	Cost Analysis & RCT	100 consecutive patients were included in this study. Inclusion Criteria: Minimum age of 18, ASA classification I-III. Exclusion Criteria: Neuropathy of sciatic or femoral nerves, impaired sensory or motor function of the lower extremities, diabetic neuropathy, Charcot-Marie-Tooth disease, local infections, systemic infections, vascular disease, inability to comprehend numeric rating scale, communication disability, dementia, BMI >35, need for bilateral surgery	Independent Variable: Major foot and ankle surgery requiring PNB. Dependent Variable: Random assignment into Ultrasound (US) and Nerve Stimulation (NS) groups	The mean cost and effects were calculated for each group. Other Variables used: Time needed to perform each intervention and amount of local anesthetic used.	The primary outcome was each intervention's cost and effectiveness analysis (mL used). The secondary outcome was the time taken to perform each intervention.	US, compared to NS, was more cost-effective. The success rate was significantly improved in terms of better coverage and cheaper 84.7% of cases compared to NS.	II	The study provides a high level of evidence of being an RCT, but the sample size is small, only including 100 patients.
McNaught, A., Shastri, U., Carmichael, N., Awad, I., Columb, M., Cheung, J., Holtby, R., & McCartney, C. (2011).	N/A	Randomized, double-blinded, up-down sequential	40 patients were included in this study. Inclusion Criteria: Age 18 years old	Independent Variable: Interscalene Block (ISB) with	The study focused on the number of needle passes needed for a	The primary outcome was to assess the effectiven	The MEAV of ropivacaine 0.5% required to provide	II	The strength of this study is the randomization of

Ultrasound reduces the minimum effective local anaesthetic volume compared with peripheral nerve stimulation for interscalene block. *British Journal of Anaesthesia*, *106*(1), 124–130. https://doi.org/10.1093/bja/aeq306		allocation study	or older, ASA I-III. Exclusion Criteria: Preexisting COPD, unstable asthma, psychiatric history, renal or hepatic impairment, allergy to ropivacaine, and opioid tolerance.	Ropivacaine 0.5%. Dependent Variables: US-Guided group and NS-Guided group	successful block and the amount of local anesthetic needed for each intervention.	ess of the block with minimal passes. The Secondary outcome was to analyze the amount of local needed for success between the US and NS groups.	postoperative analgesia in shoulder surgery for the US was 0.9 mL compared to NS, requiring 5.4 mL. All US PNB required one pass, compared to three passes with NS.		intervention and the ability to double-blind providers. The weakness of this study is the small sample size of 43 patients.
Schnabel, A., Meyer-Frießem, C., Zahn, P., & Pogatzki-Zahn, E. (2013). Ultrasound compared with nerve stimulation guidance for peripheral nerve catheter placement: A meta-analysis of randomized controlled trials. *British Journal of Anaesthesia*, *111*(4), 564–572. https://doi.org/10.1093/bja/aet196	N/A	Meta-analysis of Randomized Controlled Trials	15 RCTs with 977 patients were included. Inclusion Criteria: RCTs that compared the efficacy and safety of US vs. NS guidance for peripheral nerve catheter placement. Also, trails that used US and NS combined were included. Exclusion Criteria:	Independent Variables: Patients requiring PNB Dependent Variables: PNB placed under US, PNB placed under NS.	The study compared efficacy and safety among three techniques: US only, NS only, and US + NS in PNB.	The primary outcome of this study was to focus on the efficacy and safety profile of each technique; US-guided, NS-guided, and combined.	The study concluded that US-guided peripheral nerve catheter placement had a significantly higher overall success and lower risk of accidental vascular puncture than NS-guided catheters.	I	The strength of this study is the number of RCTs includes and the large sample size. The weakness of this trial an unclear success definition among RCTs included.

Feasibility of Regional Anesthesia									
Citation (Author, Year, Title, etc.)	Conceptual Framework (Theoretical basis for study)	Design/Methods	Sample/Setting (Number, Characteristics, Exclusions, Criteria, Attrition)	Major Variables; Definitions (Independent Variables; Dependent Variables)	Outcome Measurement (What scales used-reliability information-alphas	Data Analysis (What stats were used?)	Findings (Statistical findings or qualitative findings)	Level of Evidence Level=	Quality of evidence Strength Limits Risks Feasibility
Büttner, B., Mansur, A., Kalmbach, M., Hinz, J., Volk, T., Szalai, K., Roessler, M., & Bergmann, I. (2018). Prehospital ultrasound-guided nerve blocks improve reduction-feasibility of dislocated extremity injuries compared to systemic analgesia. a randomized controlled trial. *PLOS ONE*, *13*(7), e0199776. https://doi.org/10.1371/journal.pone.0199776	N/A	Randomized Controlled Trail	Thirty patients were included in the RCT; 18 received PNB, and 12 received analgesia. Patients 18 years and older were included in the study. Inclusion criteria were isolated injuries of extremity causing pain and requiring prehospital treatment. Exclusion criteria were preexisting nerve damage of extremity or local anesthetic allergy	Independent Variables: Extremity injuries requiring prehospital intervention Dependent Variables: The PNB group and Analgesia group received ketamine, fentanyl, and midazolam	Patient characteristics (injury and location), Pain scores were recorded via VAS. The onset of PNB and AS were recorded, If intervention were required, providers would rate the techniques as easy, intermediate, or impossible. In a blinded study, the doctor reviewed patients for pain at the scene, after the intervention, prehospital	The primary outcome was the presence of pain during the prehospital intervention. The secondary was the feasibility of reduction associated with pain scores at the scene, immediately after the intervention, and the rest of the whole day of the accident, the first and second days.	Patients with PNB exhibited more stable blood pressure than the AS group. Pronounced hypoxemia was noted in two AS patients and none via the PNB group. Providers rated 80% of patients who received PNB easy to perform reduction and only 20% as impossible, compared to the AS	II	30 patients were included in this RCT. 18 patients were placed into the Ultrasound Guided PNB, and 12 were placed into the Anglosedation group; the strength of this study includes it being a higher level of evidence and an RCT. The weakness is the small sample size.

					treatment, pain the following day, and if they would recommend the technique.		group, which rated 22.2% easy, 22.2% as intermediate, and 55.6% as impossible to reduce.		
Lee, J., Bhandari, T., Simard, R., Emond, M., Topping, C., Woo, M., Perry, J., Eagles, D., McRae, A. D., Lang, E., Wong, C., Sivilotti, M., Newbigging, J., Borgundvaag, B., McLeod, S. L., Melady, D., Chernoff, L., Kiss, A., & Chenkin, J. (2021). Point-of-care ultrasound-guided regional anaesthesia in older ed patients with hip fractures: A study to test the feasibility of a training programme and time needed to complete nerve blocks by ed physicians after training. BMJ Open, 11(7), e047113. https://doi.org/10.1136/bmjopen-2020-047113	N/A	Open-label Feasibility Study	36 emergency physicians were included in this feasibility study. Inclusion Criteria: Emergency physicians working at least one shift per week. Exclusion Criteria: Physicians already performing point-of-contract ultrasound regional anesthesia more than four times per year.	Variables in this study are emergency physicians working at least one shift per week. Each physician was given a 2-hour training class and opportunities to work with ultrasound equipment.	Patient characteristics (injury and location), Pain scores were recorded via VAS. The onset of PNB and AS were recorded, If intervention were required, providers would rate the techniques as easy, intermediate, or impossible. In a blinded study, the doctor reviewed patients for pain at the scene, after the intervention, prehospital treatment, pain the	The study's primary outcome was to determine the feasibility of providing training and providers being able to provide a successful block. The secondary outcome was determining the time until placing a successful block.	After conducting a 2-hour training class, participants could perform 87% of blocks successfully, with a median time to perform the block being 15 minutes. 94.4% of patients who received a block had a pain reduction of points. 75% of patients experienced a 50% reduction in initial pain.	III	36 emergency physicians were included in this study. The strength of this study is the sample population and trauma patients. One of the significant weaknesses in this study would be the sample population.

					following day, and if they would recommend the technique.				
McRae, P. J., Bendall, J. C., Madigan, V., & Middleton, P. M. (2015). Paramedic-performed fascia iliaca compartment block for femoral fractures: A controlled trial. *The Journal of Emergency Medicine*, *48*(5), 581–589. https://doi.org/10.1016/j.jemermed.2014.12.016	N/A	Prospective Randomized Controlled Trial	24 patients with femoral (thigh) fractures were included in this trial. Inclusion Criteria: 18 years old or older with femoral or hip fracture, pain score of 5/10 or more. Exclusion Criteria: Patients unable to understand or communicate due to cognitive impairment, language barrier, or other causes, weigh <50kg, presence of local infection at the FICB injection site, preexisting neurological deficient (sensory or motor) to the affected limb, the inability of the paramedic to	Independent Variable: Patients with femoral/hip fractures. Dependent Variable: Patients to receive FICB and Patients who solely received analgesia	The scales used during this RCT were VNPS from patients receiving interventions, Lickert scale was used to report patient satisfaction with the intervention received.	The primary outcome of this RCT was documenting the change in Verbal Numerical Pain Score (VNPS) at baseline and 15 minutes after treatment intervention. The secondary outcomes included differences in VNPS on arrival at the hospital, triage, transfer from ambulance stretcher to a bed in the ED, and at 120mins, quality of the FICB using the Likert	The study found that patients who received a FICB had more significant pain reduction in VNPS 15 minutes after the intervention than those who received analgesia alone.	III	The strength of this study is the ability to randomize patients in the field. The major weakness of this RCT is the small sample size.

			confidently identify anatomical landmarks, significant traumas, hypersensitivity to lidocaine and chronically anticoagulated patients.			scale, and reporting any adverse effects.			

Appendix F

Plan-Do-Study-Act Model