ULTRASOUND GUIDED PERICAPSULAR NERVE GROUP (PENG) BLOCK FOR HIP SURGERY: A RANDOMIZED CONTROLLED STUDY COMPARING ROPIVACAINE WITH DEXMEDETOMIDINE AND ROPIVACAINE WITH DEXAMETHASONE

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ABSTRACT

Background: Hip fractures are prevalent among the elderly and associated with significant morbidity and postoperative pain. Effective regional anesthesia techniques, such as the Pericapsular Nerve Group (PENG) block, can enhance analgesia and facilitate optimal patient positioning for spinal anesthesia. This study was conducted to compare the efficacy of ultrasound-guided PENG block using 0.5% ropivacaine combined with either dexmedetomidine or dexamethasone in patients undergoing hip surgery, focusing on pain relief during patient positioning and duration of postoperative analgesia.

Methods: This randomized controlled trial included 48 patients undergoing hip surgery under spinal anesthesia. Patients were randomized into two groups: Group A received ropivacaine with dexamethasone (8 mg), while Group B received PENG block with ropivacaine and dexmedetomidine (1 mcg/kg). Pain scores were measured using the Visual Analog Scale (VAS) at various intervals, including during patient positioning and postoperatively. The duration until first rescue analgesia and total rescue analgesic requirement were also assessed.

Results: Group B demonstrated significantly prolonged analgesia (445.0 ± 17.4 min vs. 388.9 ± 19.0 min, $p<0.05$) and reduced rescue analgesic consumption (1.9 ± 0.6 vs. 2.5 ± 0.7, $p<0.05$) compared to Group A. No significant differences were found in intraoperative hemodynamics or adverse effects.

Conclusion: PENG block is effective for facilitating patient positioning for spinal anesthesia. Adding dexmedetomidine to ropivacaine prolongs postoperative analgesia and reduces analgesic requirements more effectively than dexamethasone

INTRODUCTION

Hip injuries, particularly fractures and degenerative conditions such as osteoarthritis, are increasingly prevalent in the aging population and represent an important source of morbidity and functional decline. Surgery is frequently needed to treat these injuries, especially when femoral neck or intertrochanteric fractures occur, which are frequent in older people after low-energy trauma. Significant postoperative pain following hip surgery raises the odds of complications such deep vein thrombosis, pulmonary embolism, and postoperative delirium, delays mobilization, and lengthens hospital stays. Therefore, a key component of care for patients having hip surgery is effective perioperative pain management, especially for vulnerable older populations with numerous comorbidities[1]

Although systemic opioids and other traditional postoperative analgesic techniques are effective, they have a substantial adverse effect profile, especially in older persons. “Side effects of Opioids including fatigue, nausea, vomiting, constipation, and respiratory depression, may lessen their effectiveness and negatively affect postoperative recovery. Because they provide the benefit of localized pain treatment with a lower systemic drug burden, regional anesthetic techniques have grown in importance within the multimodal analgesia regimen for hip surgery”.

A relatively new procedure that was originally published in 2018, the Pericapsular Nerve Group (PENG) block is one of the most recent developments in regional anesthesia. This block focuses on the articular branches of the femoral, obturator, and “auxiliary obturator nerves, which are known to innervate the anterior hip capsule. In contrast to other localized blocks like the femoral nerve block, and the PENG block preserves quadriceps strength” and may allow for quicker postoperative movement by effectively creating the analgesia of the hip joint with little motor blocking.[2]

By enabling real-time imaging of anatomical features and the dissemination of local anesthetic, ultrasonography guided improves the safety and precision of the PENG block. With an increasing amount of data proving its effectiveness and safety, it has demonstrated promise in hip surgery preoperative and postoperative settings. Research is still being done to determine the best medication combinations and adjuvants to employ in PENG blocks, especially when it comes to extending the duration of analgesia and enhancing patient comfort without exacerbating adverse effects.

Because of its better safety record and lower cardiotoxicity than bupivacaine, ropivacaine, a long-acting amide-type local anesthetic, which is frequently utilized in the regional anesthesia. It is perfect for treatments like the PENG block where motor preservation is needed since it offers efficient sensory blockade with comparatively little motor blockade. Even though ropivacaine works well on its own, its duration of action may be short, hence adjuvants are needed to extend the analgesic effects.[3]

In regional anesthesia, dexmedetomidine, a selective alpha-2 adrenergic agonist, has shown promise as an adjuvant. By slowing the systemic absorption of local anesthetics through processes like vasoconstriction and nerve membrane hyperpolarization, it has been demonstrated to improve the quality and duration of nerve blocks when combined with local anesthetics. It works well as a perioperative adjuvant because of its calming and analgesic qualities.[4] Another popular adjuvant that has shown promise in extending the duration of nerve blocks is dexamethasone, a synthetic glucocorticoid. It is believed to improve the effects of local anesthetics due to its anti-inflammatory and membrane-stabilizing properties. When used at low perineural doses, it usually has few adverse effects and has been shown to enhance the quality of postoperative analgesia in a variety of regional anesthesia forms.[5]

Comparative studies are required to identify the best combination for the best analgesia, given the increasing usage of the PENG block in hip surgery and the established advantages of adjuvants “such as dexmedetomidine and dexamethasone. In ultrasound-guided” PENG blocks for patients having hip surgery, the analgesic effectiveness and safety of ropivacaine and dexmedetomidine against ropivacaine and dexamethasone will be compared in this randomized controlled research. It is anticipated that the results will help optimize regional anesthetic regimens, which would ultimately improve patient outcomes for hip surgeries.

AIMS AND OBJECTIVES

- To check the effectiveness of PENG block using ropivacaine with dexmedetomidine 1mcg/kg and ropivacaine with dexamethasone 8mg with help of pain score for patient position during neuraxiall blockade.
- To compare the duration of post operative analgesia in patients using ropivacaine with dexmedetomidine{ 1mcg/kg} to patients using ropivacaine with dexamethasone 8mg.

REVIEW OF LITERATURE

1. Epidemiology of Hip Injuries:

In many different demographics, hip injuries are a major concern, especially for athletes, senior citizens, and people who engage in a lot of physical activity. According to epidemiological research, hip injuries make up a significant percentage of musculoskeletal injuries, particularly in high-impact sports like running, road traffic accidents hockey, and football.[6]

The most frequent type of hip injury in the elderly is a fracture, which frequently happens as a result of low-energy falls. High rates of morbidity, mortality, and medical expenses are linked to these injuries. Because of osteoporosis and decreased bone mineral density, women are more likely than males to be impacted.[7] Soft tissue injuries include labral tears, hip impingement, and muscle strains are more common in athletes and younger people. Femoro-acetabular "impingement is a prevalent cause of hip pain in young adults and," if left untreated, can result in early osteoarthritis (Clohisy et al., 2013).

Age, gender, degree of exercise, and underlying medical issues all affect the frequency of hip injuries. Rehab, early diagnosis, and preventive measures are essential for lowering the long-term effects of hip injuries.[8]

2. Hip Fractures and Postoperative Pain Management:

Hip fractures are a "major global health problem because of their high prevalence and the risks" of morbidity, mortality, and long-term impairment they carry, especially for the elderly. According to the World Health Organization (WHO), an aging population and rising osteoporosis prevalence will be the main causes of the estimated 6 million hip fractures that occur each year worldwide by 2050. Even small falls in the elderly can cause complicated fractures such intertrochanteric or femoral neck fractures, which frequently call for surgery. In addition to being physically incapacitating, these fractures are associated with high levels of psychological stress, less independence, and a worse standard of living. They also cause excruciating pain; thus, they must be properly handled to avoid complications. Pain may trigger a stress response to prevent further damage to the tissue or the organism. If it continues, though, it weakens cells' and tissues' ability to respond physiologically, resulting in a pathophysiological imbalance that not only fails to sufficiently protect tissues but also raises morbidity and mortality.[9]

For patients with hip fractures, postoperative pain management is essential to their recuperation. Early mobilization is essential to avoiding problems including pressure ulcers, pneumonia, thrombosis, and muscular deconditioning, and it is made possible by adequate analgesia. It has also been demonstrated that early mobilization improves functional results and shortens hospital stays. However, because of age-related physiological changes and comorbidities that restrict the use of traditional analgesic regimens, controlling pain in elderly individuals presents special obstacles.[10]

Total hip replacement (THR) surgeries are also linked to significant perioperative discomfort, which can lengthen hospital stays and raise morbidity and healthcare costs. Orthopedic surgeons and patients still struggle greatly with perioperative pain management, even though several guidelines indicate that early surgery may lessen discomfort and cut the risk of postoperative complications and death[11]

Managing pain in older adults is particularly challenging due to the limitations of NSAIDs and the potential side effects of opioids. Therefore, after hip fractures and hip replacement surgery, effective analgesia is crucial. Advances in post-operative pain management have significantly improved the outcomes of these procedures.

However, significant post-operative pain may necessitate higher opioid dosages in post-anesthesia care facilities, a practice that should be avoided. One way to achieve this is by employing a multimodal analgesia approach, which blends numerous pain management modalities to provide adequate pain management while lowering the negative effects linked to opioids. It combines various analgesic types and techniques with various modes of action[12]

Multimodal analgesia uses a variety of methods, such as local injections, physical therapy, psychotherapy, regional anesthetics, and non-opioid medications, to effectively manage pain. This approach reduces the danger of opioid dependence and abuse while improving pain relief, speeding up healing, and reducing the demand for opioids. Within the first twenty-four hours after foot and ankle surgery, studies have shown a decrease in both hospital stays and pain levels.[13]

When periarticular injections are added to the conventional pain management strategy for hip hemiarthroplasty, postoperative opioid consumption has decreased. Similarly, surgical site injections for femur fractures and upper extremity procedures have led to better pain control and higher patient satisfaction. Adopting multimodal analgesia is crucial in orthopedic surgery to ensure comprehensive pain control and improve patient outcomes[14]

Regional anesthesia treatments are particularly helpful in hip surgeries because they offer several benefits. They improve overall pain control, decrease the need for postoperative opioids, improve dynamic pain management, lower patient morbidity and mortality, lessen financial burden, and boost patient satisfaction. There are several circumstances in which it can eliminate or reduce the need for a general anesthesia during surgery. Those who could suffer from cognitive impairment due to general anesthesia would particularly benefit from this. Additionally, in operations like total hip arthroplasty (THA), regional anesthetic is linked to positive outcomes including less blood loss and lower incidence of deep vein thrombosis (DVT[15]

Over time, numerous localized anesthetic treatments have been developed and combined to effectively reduce post-operative pain. These techniques include neuraxial local anesthetics and opioids, wound infiltration, and peripheral nerve blocks (PNBs). Regional anesthesia is becoming more popular than general anesthetic because it allows for quicker mobilization, more pain relief, and fewer post-operative nausea and vomiting.[16]

In lower limb orthopedic procedures, epidural analgesia is commonly used to reduce discomfort. Although epidural anesthesia with an indwelling catheter ensures longer-lasting pain relief, “there is a risk of serious but uncommon adverse effects” such epidural hematoma, catheter displacement, nerve damage, or epidural infection.[17]

Additionally, utilizing an epidural local anesthetic alone carries the risk of delayed mobilization and motor obstruction. When compared to other analgesic methods, nerve blocks are said to be the most effective regional anesthetic treatment for peri-operative pain management. By restricting anesthetic to the operating room, PNBs avoid the negative effects of neuraxial blocks. Furthermore, improvements in ultrasonography techniques have made regional anesthetics more reliable and effective.[18]

A recent Cochrane comprehensive study evaluated the use of PNB and systemic analgesia to treat pain after elective hip replacement surgery in adults. The review found that PNB improved patient satisfaction and reduced postoperative pain levels, while also reducing postoperative delirium and length of hospital stay[19]

3. Nerve supply of Hip Joint:

"The lumbar and sacral plexuses contribute to the hip region innervation. The anterior and posterior components of the acetabulo-femoral (hip) joint have different innervation patterns and can be separated anatomically. The femoral nerve (FN), obturator nerve (ON), and accessory obturator nerve (AON), if present, are the main innervations of the anterior side of the joint capsule. These nerves are essential for nociceptive transmission from the anterior hip, and they are particularly important when degenerative joint diseases or surgical manipulation are involved. The genitofemoral, femoral, and iliohypogastric nerves supply the cutaneous innervation to the anterior portion of the hip."

"The posterior side of the hip joint is supplied by the sciatic nerve, the" quadratus femoris nerve, and the superior gluteal nerve. This region is especially important when using lateral or posterior surgical techniques, which are frequently used in trauma and hip replacement surgeries. The lateral femoral cutaneous nerve, superior cluneal, subcostal nerve, and once more "the iliohypogastric nerve innervates the posterolateral skin over the hip. Short and Baig's anatomical investigation evaluated the innervation of the anterior hip capsule, which is where the majority of pain comes from. This study also established the connections between the high branches of FN and ON and bony landmarks. The anterior capsule of the hip joint" is regularly supplied by three nerves: FN, AON, and ON. While branches of FN and ON provide 100% of the innervation of the hip capsule, AON provides 54%.[20]

High articular branches of FN erupted above the inguinal ligament and fed all four "quadrants of the hip joint capsule. Furthermore, proximally within the obturator canal exist high branches of the obturator nerve." This explains why FNB and 3-in-1 block have a moderate effect on hip fracture pain.[21]

An anatomical study by Birnbaum K et al. revealed that the hip joint capsule's anterior and posterior sensory innervations are separate. They described the FN branches innervating "the anterior and anterolateral regions of the hip capsule, the ON supplying the antero-medially, the superior gluteal nerve innervating the posterolateral anatomy, and the articular branches from sciatic nerve and nerve to quadratus femoris providing the posterior part of the hip capsule".[22]

4. "Relevant anatomical features for the PENG block:"

"At the level where the pericapsular nerve group block is administered, several anatomical structures—including muscles, fasciae, and neurovascular components—are located between the anteroinferior iliac spine and the iliopubic eminence. From lateral to medial," the iliacus minor, iliacus, and psoas major muscles form a muscular complex. Nestled deep within this complex, lateral to the IPE, is the iliopsoas tendon, "a conjoined structure formed by the fusion of the medial tendon of the iliacus and the lateral" tendon of the psoas major.

The iliopectineal fascia, which attaches inferiorly to the IPE, envelops this entire muscular region as it expands anteromedially from the fascia iliaca. This fascial layer separates the iliopsoas complex "from the femoral neurovascular bundle and the pectineus muscle. The iliopectineal bursa," originating near the IPE, extends distally toward the lesser trochanter and anteriorly toward the joint capsule. However, it does not reach the iliopubic tract.

Within this cross-sectional anatomical zone, "the femoral nerve (FN) and the femoral branch of the genitofemoral nerve are identifiable. The FN lies anterior to the iliopsoas, while the genitofemoral branch is positioned close to the femoral artery. Given that the anterior and superolateral regions of the hip capsule are densely innervated with nociceptive fibers—more so than mechanoreceptors, and especially when compared to the posterior region—special attention has been given to the nerve pathways that innervate these parts of the capsule. These articular branches, originating primarily from the lumbar plexus, are key targets in regional anesthesia for postoperative pain control following hip" surgery.[23]

After emerging from the "lumbar plexus, the femoral nerve travels laterally through the psoas major and descends between it and the iliacus minor. It continues toward the inguinal ligament, giving off articular branches that supply all four anterior quadrants of the hip capsule. Most of these branches emerge proximal to the inguinal ligament (termed high branches), while others (low branches)" may follow a more inferior path, sometimes re-entering or piercing the iliacus minor enroute to the capsule.[24]

The obturator nerve (ON), descending medially within the psoas major, gives off articular branches that may originate before or after it enters the obturator canal. These branches contribute to the innervation of the inferolateral and inferomedial portions of the capsule. Post-division, the ON's anterior and posterior branches may also give rise to additional articular nerves located in the subpectineal space, crossing beneath the acetabulum.[25]

The accessory obturator nerve (AON), present in an estimated 8–54% of individuals, typically follows the path of the ON and then courses anterior to the IPE, running deep to the pectineus muscle to innervate the medial side of the hip capsule. Emerging research suggests the AON may be more prevalent than earlier studies indicated, with recent data showing its presence in over half of specimens examined.[26]

5. Evolution of Regional Anesthesia in Hip Surgery:

In the context of hip surgery, regional anesthesia has changed significantly due to the necessity for early mobilization, less opioid use, and efficient analgesia. Because they provide superior intraoperative anesthetic and postoperative pain management, neuraxial methods including spinal and epidural anesthesia have historically been frequently used (Hebl et al., 2005). Peripheral nerve blocks, however, have gained more attention due to worries about hemodynamic instability, urine retention, and contraindications in patients taking anticoagulants in patients undergoing neuraxial blocks.

Early peripheral techniques focused on lumbar plexus blocks and 3-in-1 blocks to anesthetize the femoral, obturator, and lateral femoral cutaneous nerves. Despite their effectiveness, these methods limited postoperative mobility due to the possibility of motor blockage. For anterior hip analgesia,"the fascia iliaca compartment block (FICB) proved to be a safer substitute with superior safety margins and effectiveness.

Recent developments in regional anesthesia, such as the Pericapsular Nerve Group (PENG) block introduced by Girón-Arango et al. in 2018, have garnered increasing attention. This technique offers focused pain relief for hip fractures and hip replacement surgeries by selectively anesthetizing the articular branches of the femoral, obturator, and accessory obturator nerves, while preserving motor function." Studies, including one by Lin et al. (2021), have shown that the PENG block effectively reduces pain levels and opioid consumption without significantly affecting quadriceps strength.[27]

6. "The Pericapsular Nerve Group (PENG) Block:"

"The articular branches of the femoral, obturator, and auxiliary obturator nerves that innervate the anterior hip capsule are the focus of the PENG block," a novel regional anesthetic procedure that was first used in 2018. By targeting these sensory nerves, the PENG block preserves motor function while providing efficient analgesia for hip procedures, allowing for early movement following surgery. By guaranteeing accurate anesthetic distribution, ultrasound guidance improves the block's precision and safety.[28]

PENG block can be used in place of "lumbar plexus block and femoral nerve block." Preventing quadriceps weakness and promoting early postoperative rehabilitation are two further benefits of PENG. According to L. Girón-Arango and colleagues, the PENG block is a targeted pain management technique used after total hip replacement (THR) surgery that offers the added advantage of sparing motor function. The approach involves injecting the anesthetic "agent into the fascial plane located between the psoas muscle and the superior pubic ramus".[29]

When it comes to analgesia for optimal posture and patient satisfaction, PENG block is more beneficial for patients having hip fracture surgery than FIB during subarachnoid block. This blocker showed a motor-sparing effect without weakening the quadriceps, making it ideal for individuals with hip fractures. Technically, taking pictures of the patient who was immobilized by traction was easy.[30]

In the postoperative phase, a PENG block in conjunction with an LFCN block may provide reliable "analgesia for THA patients. It could be a good alternative to more" intricate lumbar plexus and neuraxial blocks. Furthermore, compared to bupivacaine, ropivacaine, a long-acting local anesthetic, has a decreased propensity to cause motor blockage and less neuro and cardiovascular damage.[31]

6.1. Indications of PENG block:

Unlike previous peripheral blocks used for surgical therapy, reduce discomfort after hip and hip bone fractures are repaired surgically. Pain from hip or thigh injuries or operations is usually treated with it. (for example, femur trochanteric inter and subtrochanteric fractures, head, and neck).[30]

A PENG block may be an effective way to numb a medial thigh lesion during surgery, according to a recent study. Previous studies' authors emphasize the importance of PENG block in vascular Surgery treatments like varicose vein stripping since the ligation and stripping locations involved dermatomes that involved sensory supply from the femoral nerve and obturator. The posteromedial hip capsule is innervated by branches of the sciatic nerve and sacral plexus. During hip surgery, PENG block cannot be the only anesthetic method used[32]

6.2. Contraindications:

-Infection at injection site

-Patient decline,

-Allergy to local anesthesia, and

-Disorders of coagulation.[32]

6.3. "The PENG block procedure:"

"Based on the patient's body type, either a high-frequency linear or curvilinear ultrasound probe is typically used to perform the block with the patient lying supine. The probe is initially placed transversely over the anterior inferior iliac spine and then gradually shifted infero-medially to identify key anatomical landmarks, including the femoral artery, psoas tendon, ilio-pubic eminence, and superior pubic ramus. A blunt-tip needle (80–100 mm) is then advanced in-plane from lateral to medial, aiming for the fascial space between the psoas tendon and the superior pubic ramus. In this plane, local anesthetic—typically 20 mL of 0.25–0.5% ropivacaine or bupivacaine—is administered to bathe the articular branches of the femoral, obturator," and accessory obturator nerves.

Proper anesthetic deposition in this interfascial plane produces effective anterior hip capsule analgesia without significant quadriceps weakness, according to studies by Yu et al. (2021) and Lin et al. (2022). This makes it especially appropriate for patients with hip fractures and in the perioperative setting of total hip arthroplasty. Real-time viewing of anatomic features is made possible by ultrasound-guided procedures, which improve the block's precision and safety. However, the possibility of unintentional vascular puncture, operator skill, and anatomical variances continue to be factors in clinical practice.

6.4. Types of Techniques:

6.4.1. In plane technique:

An "ultrasound probe is first positioned transversely, just above the anterior superior iliac spine (ASIS), while the patient is in a supine position. Once the ASIS is identified, the probe is adjusted to lie parallel to the inguinal crease. By sliding the transducer medially along this alignment, important anatomical landmarks such as the psoas tendon, the iliopubic eminence (IPE), and the anterior inferior iliac spine" (AIIS) become clearly visible on the ultrasound image.[33]

Further visualization of the femoral head can be achieved by either moving the probe slightly downward or angling it caudally. For the block, a standard 22–23-gauge spinal needle is advanced using an "in-plane technique, starting from lateral to medial, targeting the space between the psoas tendon muscle and the pubic ramus." In this interfascial plane, 15 to 20 milliliters of a local anesthetic—commonly 0.5% ropivacaine—is administered. Proper care is taken during needle placement and injection to avoid injury to the psoas tendon[33]

6.4.2. "Out--plane technique:"

After administering appropriate premedication, the patient is positioned supine with hips extended. Following strict aseptic precautions, a low-frequency ultrasound probe is used, and 3 mL of 2% lignocaine is infiltrated at the intended needle entry point. The probe is aligned "parallel to the inguinal fold, at the level of the anterior superior iliac spine (ASIS), and is gently maneuvered to scan the area. By slightly shifting the probe medially, the anterior inferior iliac spine, upper pubic ramus, and psoas tendon are visualized. This technique offers the benefit of clearly identifying the psoas muscle, whose prominent tendon lies just above the pubic ramus. To accurately align the image, the AIIS should be centered to guide the needle toward the pubic ramus. A 100 mm nerve block needle is then used to inject 20–25 mL" of local anesthetic beneath the psoas tendon.[37]

6.5. "Complications:

Regional anesthesia techniques require a thorough understanding of any possible dangers involved in the process. The dangers of infection, bleeding, nerve damage, and local anesthetic toxicity. An inadvertent intravascular injection or an injection dose that beyond the hazardous limits can result in systemic toxicity from local anesthesia." In addition to other supportive treatments, hemodynamic assistance and an intravenous intralipid injection are administered immediately in the event of LA toxicity.[34]

7. Efficacy of the PENG Block in Hip Surgeries:

“The effectiveness of Pericapsular Nerve Group (PENG) block in reducing perioperative pain following hip surgery is becoming more and more supported by clinical data.” It is particularly useful for anterior hip capsule analgesia because of its focused method of anesthetizing the articular branches of the femoral, obturator, and accessory obturator nerves while maintaining motor function, which is a crucial benefit in improved recovery procedures.

Tulgar et al. (2020) showed that “giving 25 mL of 0.5% ropivacaine via PENG block dramatically decreased opioid consumption and VAS pain scores in the first 24 hours after total hip replacement in a randomized, double-blind, placebo-controlled study. Patients notably maintained” their quadriceps strength, which allowed for early mobilization.

Yu et al. (2021) conducted a prospective cohort study to assess “patients undergoing hip fracture surgery. They discovered that patients who received a PENG block” had better patient satisfaction, shorter PACU stays, and fewer intraoperative and postoperative opioid requirements than those who received standard systemic analgesia. Better preoperative pain management also led to better spinal anesthetic setting, according to the authors.

Seven clinical trials were “included in a systematic review and meta-analysis by Aliste et al. (2022), which verified that the PENG block was linked to minimal motor blockage, significantly decreased 24-hour morphine consumption, and decreased pain levels both at rest and during movement. This makes the block a good choice for patients undergoing fast-track hip surgery” as well as those in their later years.

In a study comparing the “PENG block and the Fascia Iliaca Compartment Block, Kandil et al. (2021) discovered that although both methods produced good analgesia,” the PENG block preserved quadriceps strength better, which made it especially useful for postoperative ambulation. The application of PENG blocks in the treatment of acute hip fracture pain is further supported by actual data from emergency rooms.

Morrison et al. (2021) conducted retrospective observational research in which emergency physicians safely gave PENG blocks at the patient's bedside, resulting in significant pain relief and a decrease in the need for systemic opioids in older patients with femur neck fractures.

8. Ropivacaine as a Local Anesthetic Agent:

"Ropivacaine is a long-acting amide local anesthetic that was first manufactured as a pure enantiomer. due to its capacity to reversibly inhibit sodium ion influx into nerve fibers, which is comparable to the actions of other local injectable anesthetics. Because it penetrates large myelinated motor fibers, ropivacaine has an advantage over bupivacaine in that it reduces motor blockage. Because ropivacaine has a higher degree of motor sensory discrimination, it may be useful when motor blocking is not needed." Ropivacaine prevents the conduction of nerve fiber impulses by reversibly blocking sodium ion influx. This activity is enhanced by dose-dependent potassium channel suppression. It does not affect the A fibers, which are involved in motor activity, but just the Aδ and C neurons that transmit pain.[7]

8.1. Pharmacodynamics:

Ropivacaine is considered less neurotoxic and cardiotoxic compared to some other local anesthetics, largely due to its stereoselectivity and lower lipid solubility. Its effects on the heart include a prolonged conduction time and alterations in myocardial contractility.

Studies have demonstrated that ropivacaine can inhibit platelet aggregation in plasma at concentrations commonly used for epidural injections, such as 3.75 mg/mL (0.375%) and 1.88 mg/mL (0.188%). Additionally, similar to other agents in its class, ropivacaine exhibits antimicrobial properties, showing inhibitory effects against various pathogens, "including Pseudomonas aeruginosa, Escherichia coli," and Staphylococcus aureus.[7]

8.2. Pharmacokinetics:

The plasma levels of ropivacaine are affected by various factors, such as the total amount administered, the technique of administration, the patient's cardiovascular condition, and how "vascular the injection site is. When administered intravenously, ropivacaine exhibits linear, dose-proportional pharmacokinetics up to 80 mg. It initially undergoes a rapid distribution phase with an average half-life of about 14 minutes, followed by a slower elimination phase, during which the drug has a mean absorption half-life of roughly 4.2 hours."

Because of its advantageous pharmacological profile, ropivacaine, has established itself as a standard in regional anesthesia. Ropivacaine is a safer alternative to bupivacaine because it provides efficient sensory blockade with a lower risk of CVS toxicity and CNS toxicity. This is especially true for high-risk surgical groups and the elderly.[3]

Ropivacaine's intermediate duration of effect, which typically lasts 6–12 hours depending on concentration, dose, and injection site, is one drawback despite its advantages. This has led to research into adjuvants to prolong the duration of analgesia. Using a variety of regional approaches, agents such magnesium sulfate, clonidine, dexamethasone, and dexmedetomidine have been investigated as ropivacaine additions. Perineural dexamethasone considerably increased "the duration of analgesia and decreased the requirement for rescue analgesics" without worsening side effects, according to Chaudhary et al. (2020). Prolonged analgesia is necessary in the case of hip surgery in order to cover the initial postoperative peak pain phase. As a result, ropivacaine combined with appropriate adjuvants in PENG blocks is a developing technique meant to improve analgesic effectiveness while maintaining the advantages of motor sparing.

9. Dexmedetomidine as an Adjuvant to Ropivacaine:

Dexmedetomidine, a highly selective α2-adrenergic receptor agonist, has become a valuable adjunct in regional anesthesia. Its sedative, anxiolytic, and analgesic properties, along with its ability to prolong the duration of sensory nerve blocks, make it a promising agent for enhancing the effectiveness of “techniques such as the Pericapsular Nerve Group block

9.1. Mechanism of action:

Dexmedetomidine's primary mechanism in peripheral nerve blocks is its alpha-2 adrenergic agonistic action at presynaptic nerve terminals. Here’s how it works:

Alpha-2 receptors are located on nerve terminals and, when activated, inhibit the release of norepinephrine and other neurotransmitters involved in the transmission of pain signals.

In the peripheral nervous system, activation of these receptors enhances sensory block and decreases pain signaling at the site of local anesthetic administration. This results in a prolonged analgesic effect.

Dexmedetomidine potentiates the action of local anesthetics by decreasing neuronal excitability and inhibiting nociceptive (pain-sensing) pathways in both the spinal cord and the peripheral nervous system.

The drug can also reduce the local anesthetic dose required for achieving effective analgesia, thus minimizing the risk of toxicity.

In practice, dexmedetomidine is typically added to the local anesthetic solution for brachial plexus blocks, femoral nerve blocks, or nerve blocks in orthopedic surgeries to enhance analgesia, especially in postoperative settings.

2. Pharmacodynamics in Peripheral Nerve Blockade

Dexmedetomidine provides several key pharmacodynamic effects when used as an adjuvant in nerve blocks:

Enhanced Analgesia: By acting on alpha-2 adrenergic receptors in the dorsal horn of the spinal cord, it amplifies the effect of local anesthetics. This leads to improved pain relief in the immediate postoperative period.

Prolonged Block Duration: The addition of dexmedetomidine to local anesthetics can significantly extend the duration of the block. This is particularly beneficial in surgeries requiring extended analgesia.

Sedation without Respiratory Depression: Dexmedetomidine's sedative properties enhance the patient experience, providing a state of light sedation that is easily reversible if needed. The advantage is that it does not cause significant respiratory depression, a risk often seen with opioids.

Reduced Need for Opioids: By enhancing local analgesia, dexmedetomidine helps decrease reliance on opioids in the postoperative period, reducing the risk of opioid-related side effects (e.g., nausea, vomiting, sedation, respiratory depression).

Sympatholytic Effects: Dexmedetomidine has mild vasodilatory effects that help to reduce the sympathetic response to surgery, contributing to better hemodynamic stability during and after the procedure.

3. Pharmacokinetics in Peripheral Nerve Blockade

The pharmacokinetics of dexmedetomidine, while similar to its systemic use, play an important role when administered as an adjuvant in nerve blocks:

Absorption: When used locally in a nerve block, dexmedetomidine is rapidly absorbed into the surrounding tissues and peripheral nerves after being injected, although its bioavailability and absorption depend on the method of delivery.

Distribution: Dexmedetomidine is lipophilic and quickly diffuses across nerve membranes into the nerve roots and spinal cord, exerting its action on both peripheral nerves and the central nervous system. It thus prolongs the analgesic effects beyond the immediate injection site.

Plasma Half-life: When given locally for nerve blocks, dexmedetomidine's pharmacokinetics are less predictable than when given intravenously. However, systemic absorption from the local site may contribute to a half-life of 2 to 3 hours, which supports extended effects on pain relief.

Volume of Distribution: As with systemic administration, dexmedetomidine distributes extensively throughout the body, but because it is injected directly near the nerve or surgical site, the concentration near the action site is significantly higher, providing more localized effects.

4. Metabolism in Peripheral Nerve Blockade

When used as an adjuvant in nerve blocks, dexmedetomidine undergoes extensive hepatic metabolism, even though the drug is primarily administered locally or regionally:

Cytochrome P450 Enzyme System: Dexmedetomidine is metabolized by CYP2A6 and CYP1A2 enzymes in the liver, producing inactive metabolites that do not contribute to the drug's pharmacological activity.

Minimal Systemic Effects: Since dexmedetomidine is administered near the site of the nerve block, the systemic absorption is minimal, reducing the potential for widespread metabolism. However, should there be significant absorption, it will follow the typical hepatic metabolic pathways.

5. Excretion in Peripheral Nerve Blockade

Dexmedetomidine is primarily excreted through the urine as inactive metabolites. The rate of systemic absorption after regional administration is generally low, so systemic excretion is minimized compared to intravenous use. However, if significant amounts enter the bloodstream:

Excretion via Urine: Approximately 95% of dexmedetomidine and its metabolites are eliminated via the renal system.

Minimal Fecal Excretion: Only a small fraction is excreted in the feces, with most of the drug being cleared through the kidneys.

Dexmedetomidine has been shown in numerous clinical investigations to be an effective adjuvant for a variety of peripheral nerve blocks. “The addition of dexmedetomidine to ropivacaine in interscalene brachial plexus blocks considerably extended the duration of both sensory and motor block without raising problems, according to a RCT conducted by Brummett et al. (2008). Similarly, Kandil et al. (2016) discovered that femoral nerve blocks for total knee arthroplasty” that included dexmedetomidine in addition to ropivacaine produced extended analgesia, improved pain scores, and decreased the need for postoperative analgesics.[22]

Although research on the PENG block specifically is still in its infancy, evidence from related regional procedures suggests that it is useful in the context of hip surgery. In a trial employing fascia iliaca blocks, Rancourt et al. (2020) shown that perineural dexmedetomidine added to ropivacaine considerably enhanced patient comfort without causing sedation-related adverse effects or motor impairment, and extended the duration of analgesia by several hours.

Abdallah et al. (2019) conducted a meta-analysis of several peripheral nerve blocks and found that dexmedetomidine, when given as an adjuvant, improves overall pain control, decreases 24-hour opioid usage, and extends the duration of sensory blocks by about 4–6 hours. Crucially, the safety profile was good, with few cases of hypotension and bradycardia, especially at lower dosages (25–50 mcg).[35]

Dexmedetomidine is believed to improve block quality by a combination of mechanisms, including suppression of norepinephrine release, hyperpolarization of nerve tissues, and vasoconstriction, which prolongs the effects of the local anesthetic by slowing systemic absorption. Since ropivacaine alone usually lasts 8 to 12 hours with PENG blocks, adding dexmedetomidine provides a useful way to prolong analgesia into the crucial early postoperative phase. Although there is currently little direct data on dexmedetomidine's effectiveness in PENG blocks, its potential usefulness in this context is supported by its motor-sparing properties and success inferred from other blocks.[36]

10. Ropivacaine with Dexamethasone as an Adjuvant:

It has little to no mineralocorticoid activity and is a strong glucocorticoid. It limits the expansion of lymphocyte colonies. Prostaglandin, interleukin-1,12,18, and tumor necrosis factor are all suppressed, while blood levels of vitamin A compounds are elevated. Dexamethasone has also been demonstrated to enhance pulmonary circulation and raise surfactant levels. The liver metabolizes dexamethasone extensively, and the chemicals are eliminated through urine.

9.2. Pharmacokinetics:

Absorption: Dexamethasone reaches peak plasma concentrations on average about one hour after administration, with a range between 30 minutes and 4 hours. After a single 20 mg dose, the maximum concentration is decreased by about 23% when taken with a high-fat, high-calorie meal.

Metabolism and Elimination: Dexamethasone is primarily "metabolized by the cytochrome P450 enzyme CYP3A4. It has an average terminal half-life of around four hours." Renal clearance accounts for less than 10% of total drug elimination, with only a small fraction excreted unchanged in the urine.[36]

The effectiveness of dexamethasone as an additive in different peripheral nerve blocks is supported by an increasing amount of clinical research. When dexamethasone (8 mg) was "added to ropivacaine in interscalene blocks for shoulder surgery, the length of the block extended by more than 50% when compared to ropivacaine alone, according to a randomized controlled trial by Parrington et al. (2010). In a meta-analysis, Choi et al. (2014) reported similar results, concluding that perineural dexamethasone prolongs analgesia in brachial plexus blocks by 8–12 hours[37]

According to Cummings et al. (2011), dexamethasone added to ropivacaine in femoral and sciatic nerve blocks" produced noticeably longer pain relief and a decreased requirement for rescue analgesics in lower limb blocks. Although perineural delivery of the dexamethasone had somewhat better results in several studies, these benefits were consistent whether the drug was given intravenously or perineally.[38]

Extrapolation from neighboring blocks encourages its use, notwithstanding the existing paucity of data on its application with PENG blocks. Sakae et al. (2021), for example, assessed the use of ropivacaine and dexamethasone in fascia iliaca blocks and discovered that patients having hip arthroplasty experienced sustained postoperative analgesia. In the case of PENG blocks, it is feasible to assume equivalent benefits due to the identical innervation targets and anesthetic planes. Dexamethasone may function mechanistically by lowering perineural inflammation, inhibiting prostaglandin synthesis, and maybe through genetic effects that modify nociceptive pathways. Longer analgesia, reduced pain sensitivity, and increased postoperative patient comfort are all facilitated by this.

Crucially, consistent efficacy and a robust safety profile have been demonstrated by low doses of dexamethasone (4–8 mg). Animal and clinical research have largely allayed worries regarding neurotoxicity by demonstrating that at widely used concentrations, there is no discernible harm to perineural tissue.

11. Comparative Studies of Dexmedetomidine and Dexamethasone:

As proven adjuvants to local anesthetics like ropivacaine, dexmedetomidine and dexamethasone each have special advantages in regional anesthesia. Although both substances increase the length of sensory blocking and enhance analgesic effects, direct comparative investigations have produced conflicting and occasionally inconclusive findings about whether substance is more effective.

Compared to dexamethasone (8 mg), dexmedetomidine (1 µg/kg) administered to ropivacaine produced a quicker onset and longer duration of both sensory and motor blocks in a randomized controlled experiment by Swami et al. (2017) utilizing supraclavicular brachial plexus blocks. Additionally, the dexmedetomidine group showed improved postoperative analgesia and greater patient satisfaction, according to the study.

However, in a study using interscalene blocks, Choi et al. (2020) reported conflicting results, finding that dexamethasone produced a longer-lasting analgesic effect, even if its start time was slightly slower than that of dexmedetomidine. The authors hypothesized that dexamethasone's anti-inflammatory and genomic properties may be responsible for its prolonged impact, especially in blocks that target deeper or more inflammatory tissue.[37]

When Kaur et al. (2021) compared dexamethasone and dexmedetomidine across several peripheral nerve blocks, they came to the following conclusion that Dexmedetomidine exhibited superior block density and a faster onset. Dexamethasone provided postoperative analgesia for a longer period of time, particularly in blocks for orthopedic procedures. Both adjuvants were well-tolerated with a low frequency of adverse effects and were similarly efficient in lowering opiate usage.

Ahmed et al. (2022) evaluated the two agents in femoral nerve blocks for total knee replacement in the setting of lower extremity nerve blocks. Patients in the dexmedetomidine group exhibited mild drowsiness and bradycardia, whereas those in the dexamethasone group did not; nevertheless," the study did not find a statistically significant difference in the duration of analgesia." These results might affect the choice of patients, particularly in older or hemodynamically vulnerable groups having hip surgery. Robust head-to-head trials comparing dexmedetomidine and dexamethasone particularly in PENG blocks are currently lacking. On the other hand, extrapolating from other regional methods:

• When a quicker start and denser block are sought (for example, preoperative use or expected severe pain load), dexmedetomidine can be the better option. In cases when motor-sparing and prolonged pain relief are necessary for early ambulation, dexamethasone may be preferred for prolonged postoperative analgesia.

12. Existing Literature Review:

Anwar-u-Huda and Hashsaam Ghafoor conducted a meta-analysis that comprised six RCTs. Their findings "demonstrated that PENG block use for patients undergoing hip surgery was linked to improved patient satisfaction, a lower likelihood of motor block, and a significant decrease in opioid consumption during the first 24 hours "after surgery.[2]

A comparison analysis was conducted by Priyanka Krishnamurthy et al. on 40 patients who had hip fracture surgery. For post-operative analgesia, they contrasted PENG block with USG-guided FIB. According to the study's findings, PENG block offers superior analgesia for SAB placement and a similar amount of trouble-free postoperative analgesia.[39]

The usefulness of "PENG block in reducing perioperative pain in patients having hip arthroscopies was investigated" by Fernicola MD et al. Common side effects of standard regional blockades include postoperative lower limb weakness and mobility difficulties. They came to the conclusion that, in comparison to traditional regional anesthetic procedures, PENG block provides a limited neuromuscular blockade and an effective and targeted sensory nerve block, while also reducing the need for opioids after surgery.[40]

In 42 patients with a fractured femoral neck, Celine Allard et al. compared the "PENG block to the femoral block. Prior to surgery, the patients were given either a femoral block or a PENG block. They came to the conclusion that the two groups' postoperative morphine use did not differ significantly."

Nonetheless, PENG block greatly increases the operated limb's early mobility, making it a useful addition to an improved rehabilitation regimen.[41]

Pascarella et al. examined the impact of the PENG block in individuals undergoing total hip replacement. Their study, which involved 66 participants, revealed that those who received the PENG block reported significantly lower pain levels after surgery. Furthermore, these patients required fewer opioids, showed improved hip movement, and regained the ability to walk in a shorter time compared to those who did not receive the block.[42]

"A case series of ten patients who had surgery" for a hip fracture under SAB with a preoperative PENG block and continuous local anesthetic infusion via catheter inserted during PENG block was published by Swati Singh et al. They came to the conclusion that none of the patients needed further painkillers. Problems like paraesthesia, weakness in the quadriceps, catheter migration, and local anesthetic toxicity did not occur in any of the patients.[43]

Micol Sandri et al. evaluated "the efficacy of utilizing PENG block in conjunction with local infiltration (LIA) as the only anesthetic technique for hip replacement surgery. Ten patients with ASA 1 or 2 who only received direct anterior approach surgery were examined for the effectiveness of PENG and LIA. For LIA, they employed a combination of morphine, epinephrine, ketorolac, and levobupivacaine. Using the direct anterior route, they came to the conclusion that PENG block plus LIA can be a safe and efficient anesthesia technique for Total hip arthroplasty." This method reduces intraoperative blood loss, improves postoperative analgesia, and produces the best anesthesia possible.[44]

The CNS and CVS effects of intravenous ropivacaine and bupivacaine have been compared by K. Knudsen et al. In comparison to bupivacaine, they found that ropivacaine had higher unbound plasma levels and a more manageable dosage. Ropivacaine also has CVS effects, including as decreased diastolic function and conduction, at levels that cause CNS symptoms.[45]

MATERIAL & METHOD

Study Design: Parallel design randomized controlled trial study.

Study Duration: From May 2023 to April 2025.

Study Participants: This "study was conducted on adult patients posted for hip surgery at R. L. Jalappa Hospital and Research Centre, Tamaka, Kolar."

Sampling Method: The type of sampling employed was Universal sampling. Randomization of the sample was done by software with 1:1 allocation using block randomization with unequal block size.

Sample Size Calculation:

The sample size formula that was used for this study is given below:

The formula for calculating the minimum required sample size is:

$N = [(2 \times (z_{1-\alpha/2} - z_{1-\beta}))^2 \times \sigma^2] / d^2$

Where:

- N represents the minimum number of subjects needed for the study.

- $z_{1-\alpha/2}$ is the critical value obtained from the standard normal distribution table, indicating the threshold the test statistic must surpass to achieve statistical significance at a given level of alpha (α).

$z_{(1-\beta)}$ = Standard normal table value for the power of the test (1-β)

σ = Standard deviation of the response variable (obtained from previous study

"d = the effect size = the minimum clinically important difference that the investigator wishes to detect."

In the present study,

Investigator assumed a minimum difference of 17 min mean duration of first rescue analgesic required would be important to detect clinically. So, d =17.

In the previous study Balasubramaniam et al., 2023, SD of two groups have 19.00 and 17.4 in the ropivacaine-clonidine combination while with ropivacaine-dexmedetomidine combination. Hence, pooled variance computed is 18.22.[46]

ie. p = 18.22.

Next, each group's minimum necessary sample size was calculated to be 24.

Thus, a total of 2 x 24 = 48 patients is required for the present study

N=48.

Inclusion Criteria:

Individuals over the age of eighteen who have physical statuses 1-3 according to the American Society of Anaesthesiologists (ASA) are scheduled for elective hip fracture surgery under spinal anesthesia.

Exclusion Criteria:

- Patients who refused to participate in the study
- Local anaesthetic allergy
- Coagulopathy- Increased PT, INR, aPTT and decreased platelet count
- Infection at site of block

Data collection Procedure:

- Following “registration with the Clinical Trials Registry-India (CTRI)” and

Institutional Ethical Clearance (IEC), the trial was initiated. Following the acquisition of written, informed consent, patients were added to the research. Adult patients over the age of 18 who needed hip surgery were the subjects of the study.

- The coagulation profile (platelet count, PT, INR, and aPTT) and routine examinations were completed and recorded.
- The maintenance intravenous fluids were administered and the intravenous line was secured.
- After being positioned before a PENG block, “patients were asked to rate the level of discomfort” based on their VAS score. This was done every five minutes until thirty minutes after the patient was positioned for spinal anesthesia.

Group A: Receiving PENG block with 20 ml of 0.5% Ropivacaine with dexmedetomidine (1.cg/kg)

Group B: Receiving PENG block with 20 ml of 0.5% Ropivacaine with Dexmedetomidine(1mcg/kg).

Following the block, all patients underwent spinal anesthesia in the “sitting position at the L3–L4 level using 3 mL of 0.5% hyperbaric bupivacaine with 25 mcg fentanyl via a 25G Quincke spinal needle under strict aseptic precautions.”

Patients were continuously monitored intraoperatively for:

- Heart Rate (HR)
- VAS scale
- Non-Invasive Blood Pressure (NIBP)
- Peripheral Oxygen Saturation (SpO_2)

Any adverse effects or complications were recorded.

Statistical Analysis:

- Qualitative characteristics will be represented in terms of frequency and percentages.
- Quantitative characteristics will be represented in terms of mean and standard deviations.

  • The z-test for two independent proportions, “chi square test, or Fisher's exact test, as appropriate, will be used to compare categorical variables.
- Depending on the dependent variables' normality assumptions, either the independent t-test or the Mann Whitney U test was used to compare quantitative variables between two groups.”
- Shapiro-Wilk's test will be used to test the normality assumptions of the quantitative variable observations.
- A P-value below 0.05 is regarded as statistically significant.

The study was conducted on 48 participants, out of which 64.6% (31 participants) were male and 35.4% (17 participants) were female.

Table 1: Gender distribution in the study

Gender		
	N	%
Male	31	64.6%
Female	17	35.4%

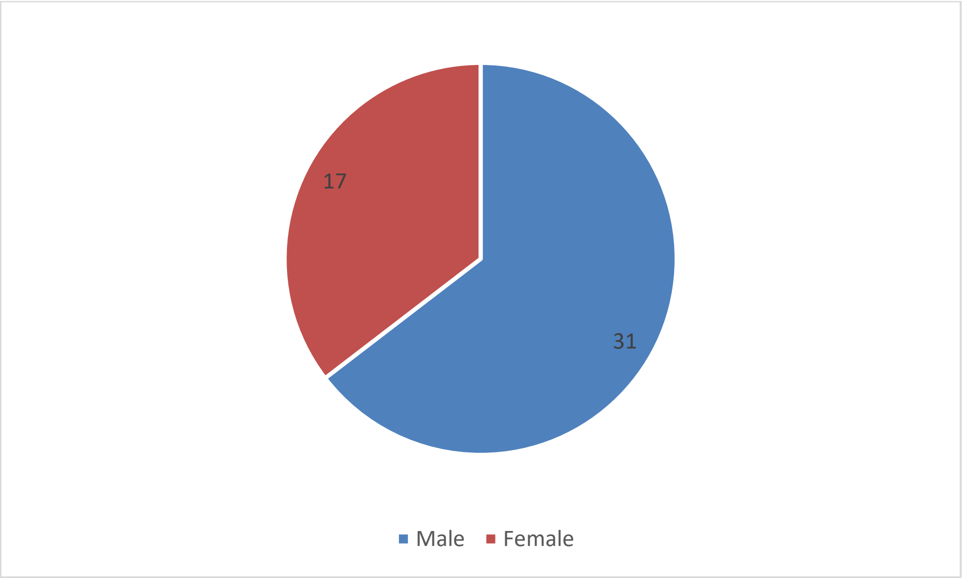

Figure 1: Gender distribution in the study

Participants were categorized into four age groups. The largest age group was individuals over 71 years, comprising 41.7% (20 participants). This was followed by those aged 61–70 years at 37.5% (18 participants), 51–60 years at 14.6% (7 participants), and under 50 years at 6.3% (3 participants).

Table 2: Age distribution in the study

Age Category		
	N	%
<50 years	3	6.3%
51-60 years	7	14.6%
61-70 years	18	37.5%
>71 years	20	41.7%

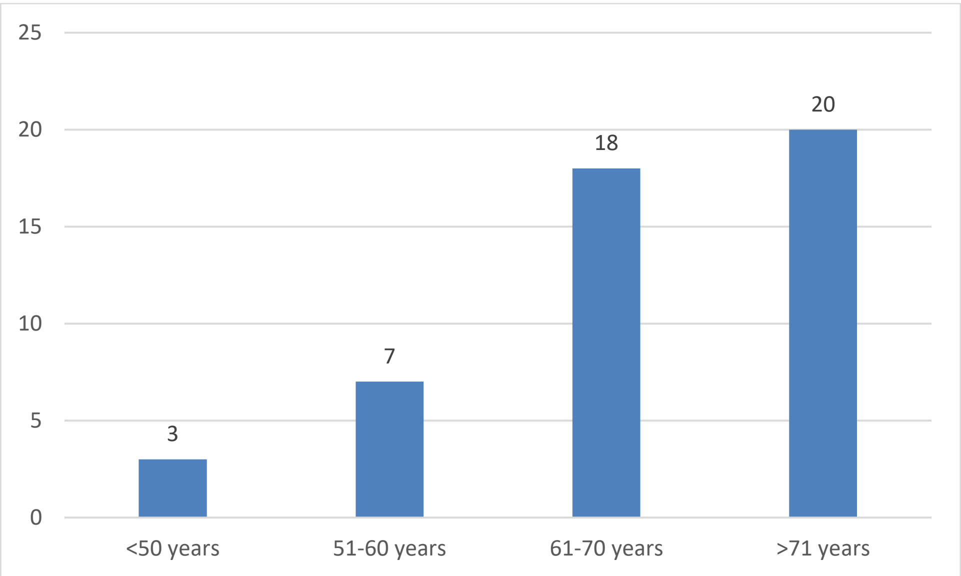

Figure 2: Age of participants in the study

Among the participants, 39.6% (19 participants) were classified as ASA Grade III, 33.3% (16 participants) as Grade I, and 27.1% (13 participants) as Grade II.

Table 3: ASA grade in the study

ASA grade		
	N	%
Grade I	16	33.3%
Grade II	13	27.1%
Grade III	19	39.6%

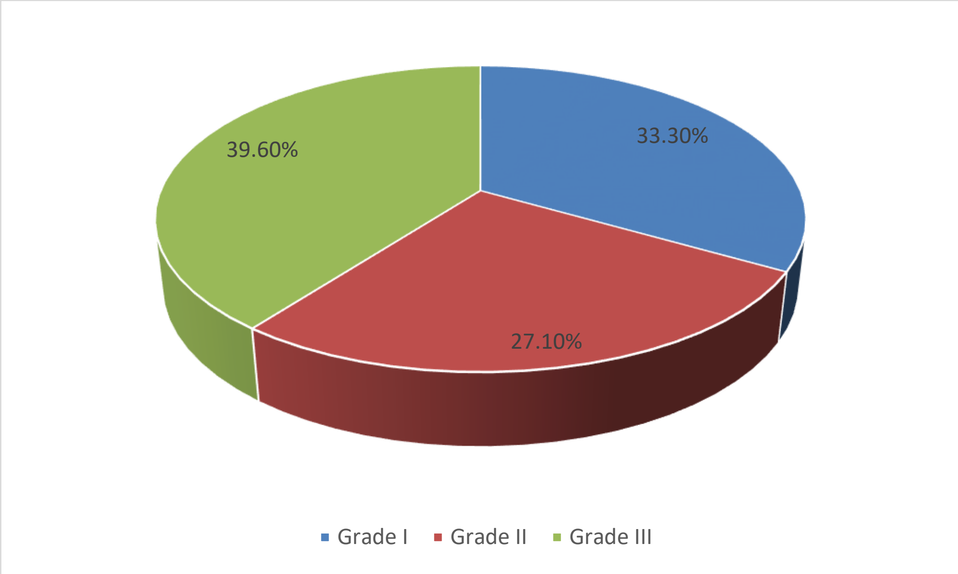

Figure 3: ASA grade within the study

The types of surgeries performed included Total Hip Replacement (THR) in 41.7% (20 cases), Hemiarthroplasty in 31.3% (15 cases), and DHS Fixation in 27.1% (13 cases).

Table 4: Type of surgery in the study

Surgery		
	N	%
THR	20	41.7%
DHS Fixation	13	27.1%
Hemiarthroplasty	15	31.3%

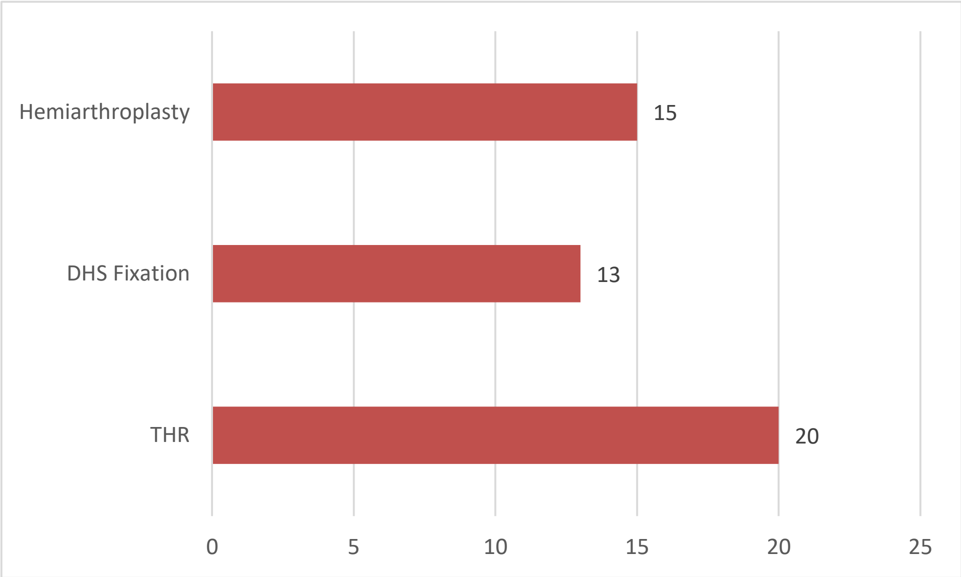

Figure 4: Frequency of type of surgery

In Group A, most participants (50%) were aged 61–70 years, while in Group B, the majority (50%) were over 71 years old. Other age distributions were more evenly spread across both groups. “The chi-square test showed no significant difference in age distribution between the groups” ($p = 0.220$).

Table 5: Age Category distribution within the randomized groups

		Group			
		Group A		**Group B**	
		N	**%**	**N**	**%**
Age Category	<50 years	2	8.3%	1	4.2%
	51-60 years	2	8.3%	5	20.8%
	61-70 years	12	50.0%	6	25.0%
	>71 years	8	33.3%	12	50.0%
Total		24	100.0%	24	100.0%
p-value		0.220			

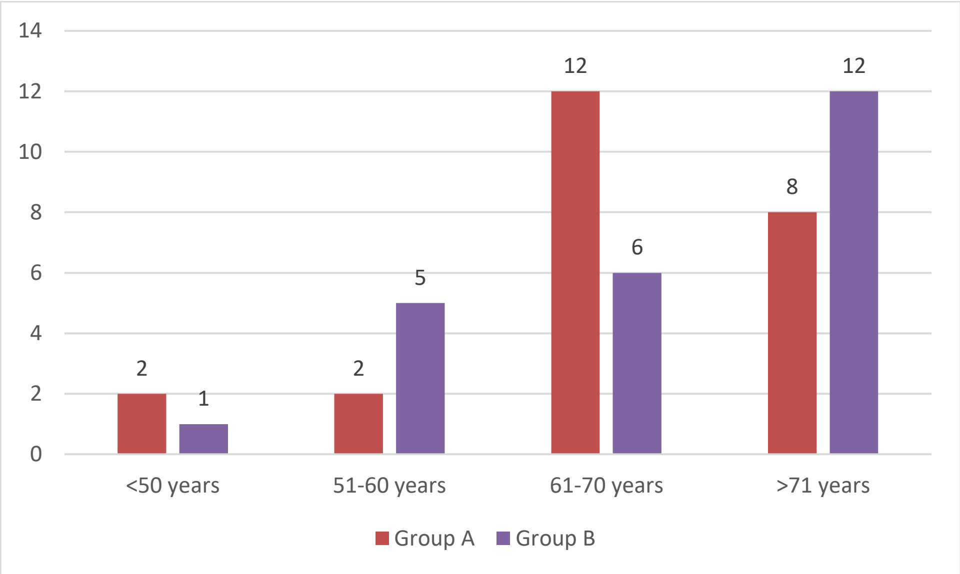

Figure 5: Age categories in the groups

Group A had 66.7% males and 33.3% females, while Group B had 62.5% males and 37.5% females. The distribution of gender "was found to be not statistically different within the two groups" (p = 0.763).

Table 6: Distribution of Gender within the group

		Group			
		Group A		Group B	
		N	%	N	%
Gender	Male	16	66.7%	15	62.5%
	Female	8	33.3%	9	37.5%
Total		24	100.0%	24	100.0%
p-value		0.451			

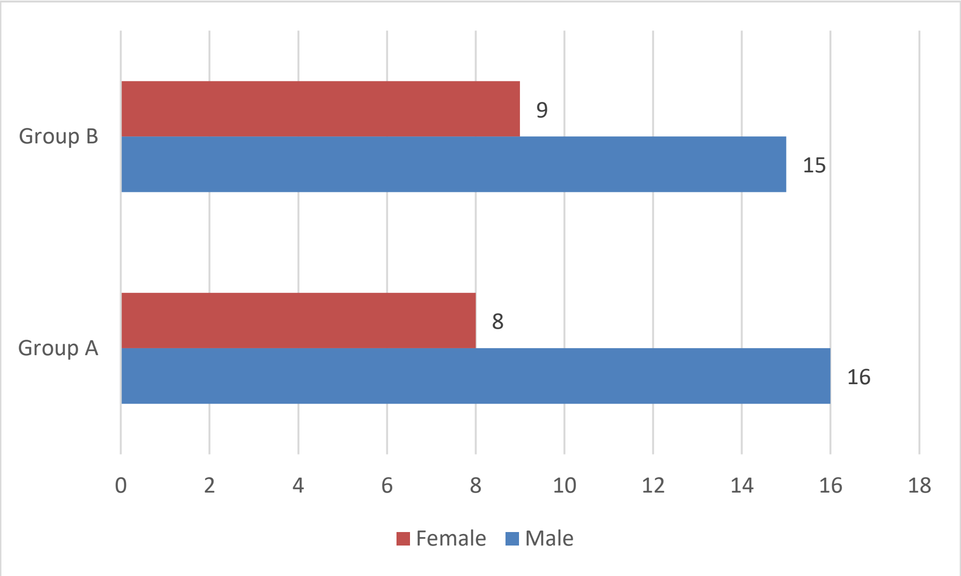

Figure 6: Gender distribution within the groups

In Group A, 50% were ASA “Grade I, 16.7% Grade II, and 33.3% Grade III.” In Group B, 16.7% were Grade I, 37.5% Grade II, and 45.8% Grade III. A statistically significant difference was noted in ASA grade distribution (p = 0.041).

Table 7: ASA grade within the randomized groups

		Group			
		Group A		Group B	
		N	%	N	%
ASA grade	Grade I	12	50.0%	4	16.7%
	Grade II	4	16.7%	9	37.5%
	Grade III	8	33.3%	11	45.8%
Total		24	100.0%	24	100.0%
p-value		0.041			

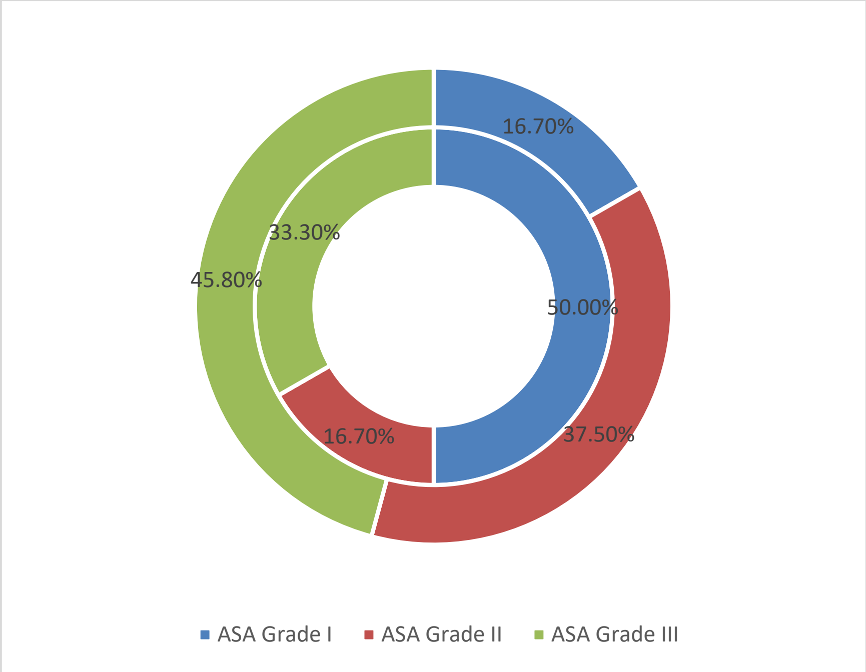

Figure 7: ASA grade within the groups

Group A had 33.3% THR, 37.5% DHS Fixation, and 29.2% Hemiarthroplasty. Group B had 50% THR, 16.7% DHS Fixation, and 33.3% Hemiarthroplasty. The differences were not statistically significant (p = 0.248).

Table 8: Type of Surgery within the randomized groups

		Group			
		Group A		Group B	
		N	%	N	%
Surgery	THR	8	33.3%	12	50.0%
	DHS Fixation	9	37.5%	4	16.7%
	Hemiarthroplasty	7	29.2%	8	33.3%
Total		24	100.0%	24	100.0%
P-value		0.248			

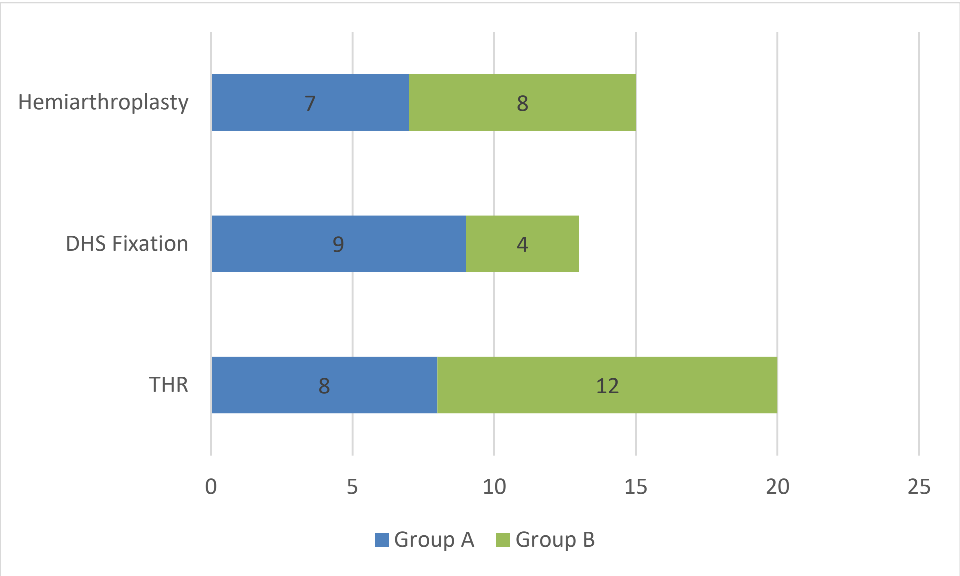

Figure 8: Surgeries within the groups

Group B's mean age was 75 years, whereas in Group A was 72 years. The BMI, height, and weight of the two groups were comparable. These physical parameters did not differ in a way that was statistically significant.

Table 9: Means and SDs of variables within the randomized groups

	Group-A		**Group-B**		
	Mean	**SD**	**Mean**	**SD**	**p-Value**
Age	72	7.3	75.0	7.0	0.74
Weight	65.9	9.2	66.4	9.6	0.85
Height	166.67	8.89	164.8	9.1	0.49
BMI	22	1.2	22.6	1.8	0.19

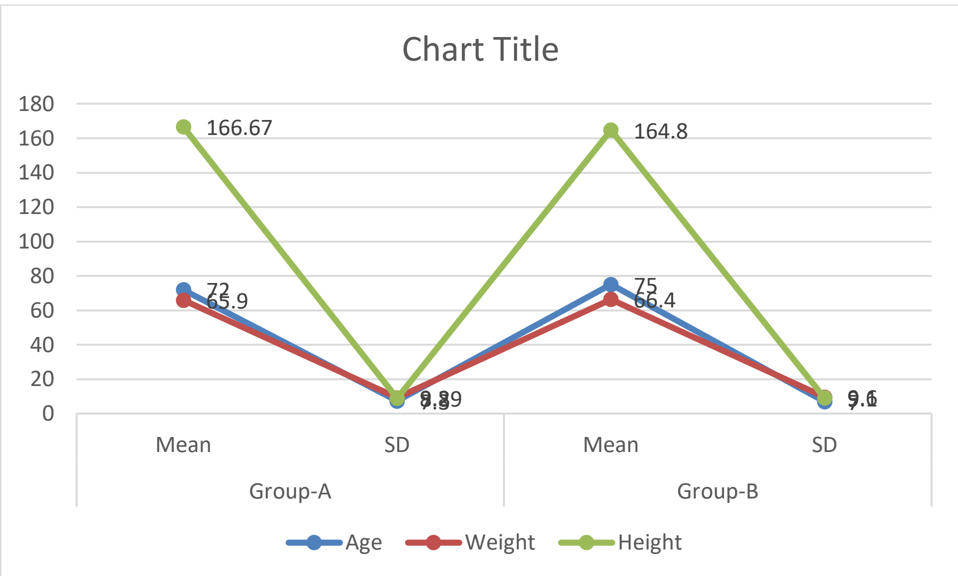

Figure 9: Age and anthropometry mean in both groups

Heart rates were comparable between both groups at all time points from baseline to 30 minutes post-block. None of the time points showed statistically significant differences.

Table 10: Heart rate during PENG block within the randomized study population.

	Group-A		Group-B		
Heart Rate	**Mean**	**Std Dev**	**Mean**	**Std Dev**	**p-Value**
Baseline	80.3	11.3	77.9	11.6	0.23
At the time of Block	79.2	13.8	77.4	12.7	0.65
5 mins after block	77.3	11.9	78.4	11.4	0.75
10 minutes after block	80.2	12.8	83.3	12.1	0.39
15 mins after block	80.3	11.7	81.6	12.6	0.71
20 mins after block	78.3	12.1	78.1	12.4	0.96
25 mins after block	74.3	11.6	79.0	12.8	0.20
30 mins after block	79.2	12.1	79.2	13.1	0.99

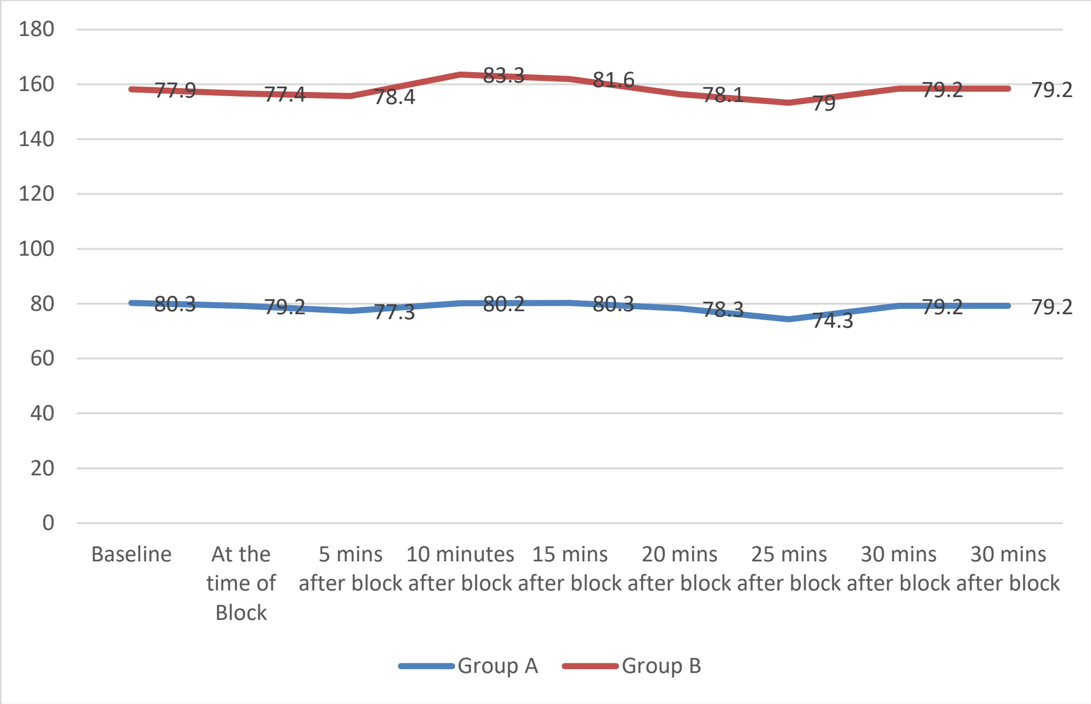

Figure: 10 Mean heart rates in both groups during PENG block

During spinal anesthesia block (SAB), heart rates remained comparable between Group A and Group B at all measured intervals, with no statistically significant differences observed. Mean heart rates ranged from 76.8 to 73.9 bpm in Group A and from 78.2 to 74.7 bpm in Group B, with p-values consistently above 0.05.

Table 11: Heart rate during SAB within the randomized groups

	Group-A		Group-B		
Heart Rate	**Mean**	**Std Dev**	**Mean**	**Std Dev**	**p-Value**
At the time of SAB	76.8	10.6	78.2	11.2	0.63
5 mins after SAB	75.1	10.1	76.5	10.3	0.58
15 minutes after SAB	74.4	9.9	75.2	10.1	0.76
30 mins after SAB	73.9	9.8	74.7	10.0	0.69

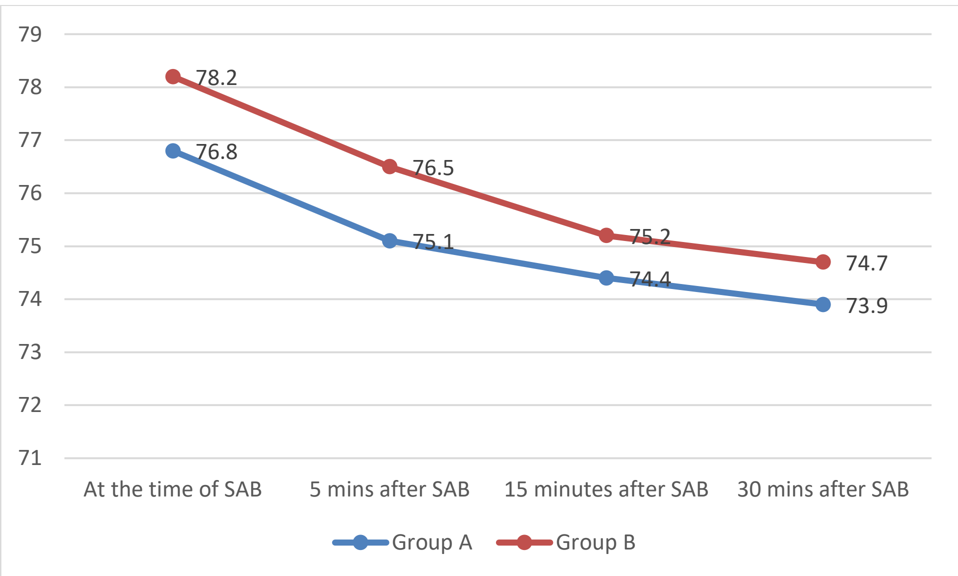

Figure 11: Heart Rate means during SAB in the study

Mean arterial pressure was "comparable between Group A and Group B at all time points during the PENG block," with no statistically significant differences observed. Values ranged from 87.5 mmHg at baseline to 81.4 mmHg at 30 minutes in Group A, and from 86.7 mmHg to 86.2 mmHg in Group B, with p-values consistently above 0.05 throughout the observation period.

Table 12: Mean arterial pressures during PENG block within the randomized groups

	Group-A		**Group-B**		
Mean Arterial pressure	**Mean**	**Std Dev**	**Mean**	**Std Dev**	**p-Value**
Baseline	87.5	8.6	83.5	9.9	0.23
At the time of Block	84.2	9.6	86.7	8.9	0.65
5 mins after block	86.6	9.3	85.4	8.6	0.75
10 minutes after block	86.5	9.7	86.8	8.11	0.39

15 mins after block	84.6	9.8	86.08	8.37	0.71
20 mins after block	83.5	9.14	85.4	10.2	0.96
25 mins after block	82.9	9.98	87..6	8.95	0.20
30 mins after block	81.4	8.78	86.2	8.06	0.99

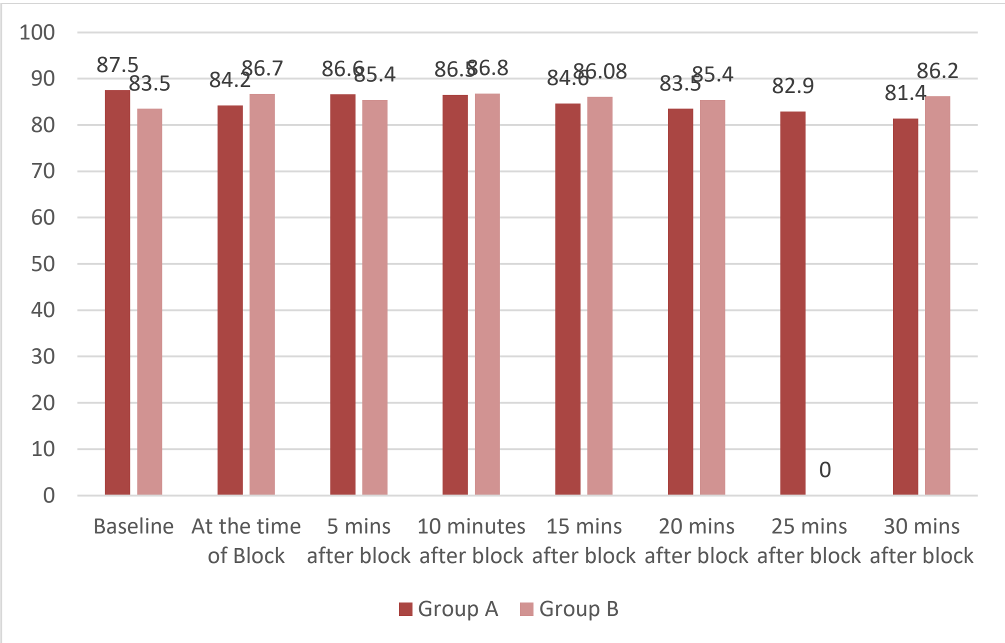

Figure 12: MAP during PENG block in the groups

During spinal anesthesia block (SAB), mean arterial pressures remained similar between Group A and Group B at all measured intervals. At the time of SAB, the mean pressures were 82.6 mmHg in Group

A and 84.1 mmHg in Group B (p = 0.51), with comparable values continuing at 5-, 15-, and 30-minutes post-SAB. None of the differences were statistically significant, indicating stable hemodynamic profiles across both groups.

Table 13: Mean arterial pressures during SAB in the randomized groups

	Group-A		**Group-B**		
Mean Arterial pressure	**Mean**	**Std Dev**	**Mean**	**Std Dev**	**p-Value**
At the time of SAB	82.6	8.5	84.1	8.3	0.51
5 mins after SAB	81.2	8.3	82.7	8.0	0.46
15 minutes after SAB	80.4	8.1	81.9	7.9	0.48
30 mins after SAB	79.8	7.8	81.1	7.7	0.52

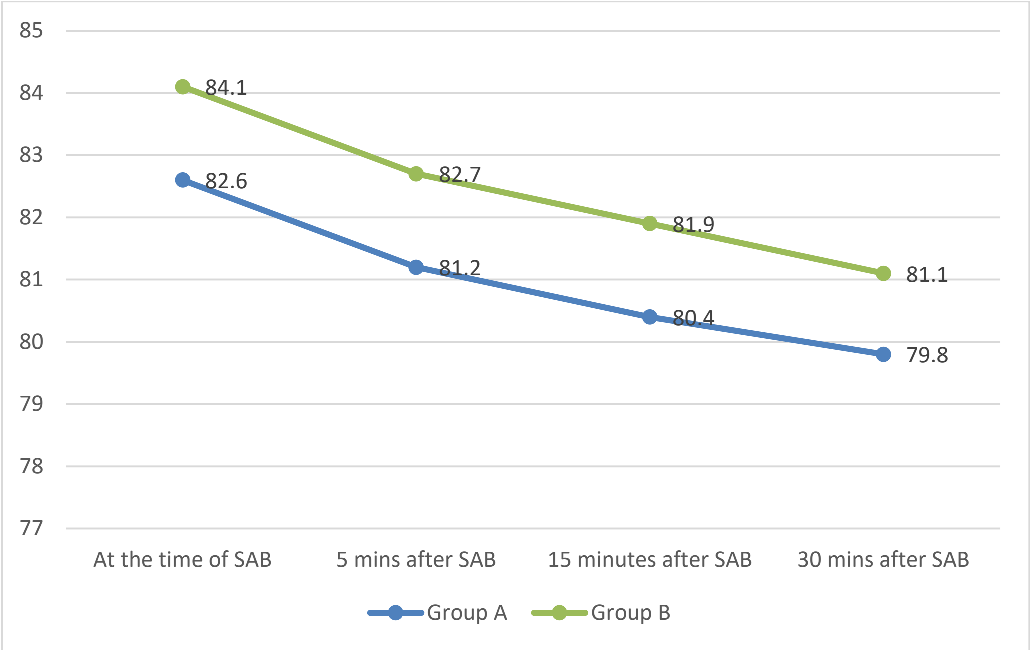

Figure 13: MAP in both groups during SAB

“The VAS scores at rest between Group-A and Group-B were largely comparable at most time points, with no significant differences observed from baseline up to 24 hours post-block, except at the 6-hour mark. At baseline and immediately after the block, both groups had similar pain scores ($p > 0.05$). Notably, at 6 hours after the block, Group-B reported significantly” higher pain (2.9 ± 1.2) compared to Group-A (2.2 ± 1.1), with a p-value of 0.01.

Table 14: VAS rest during PENG block within the randomized groups

	Group-A		Group-B		
VAS at Rest	**Mean**	**Std Dev**	**Mean**	**Std Dev**	**p-Value**
Baseline	1.88	1.4	2.0	1.5	0.72
At the time of Block	2.3	1.4	2.3	1.6	1.0
5 mins after block	2.0	1.7	1.9	1.5	0.74
10 minutes after block	2.7	1.2	2.1	1.4	0.13
15 mins after block	2.2	1.5	2.1	1.4	0.81
20 mins after block	2.3	1.6	2.0	1.5	0.54
6 hours after block	2.2	1.1	2.9	1.2	0.01
12 hours after block	2.5	1.2	2.6	1.1	0.62
24 hours after block	2.7	1.3	2.9	1.2	0.59

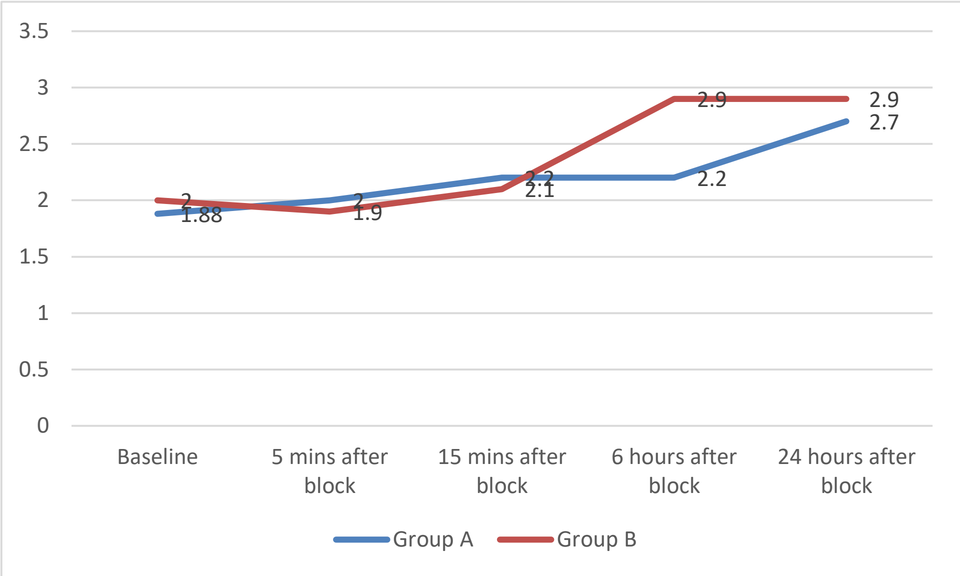

Figure 14: VAS-rest in the PENG block at various times in the groups

VAS scores at rest during SAB demonstrated a trend of better pain relief in Group B compared to Group A, with the difference becoming statistically significant as time progressed. While both groups started with similar scores at the time of "positioning (2.6 in Group A vs. 2.3 in Group B, p = 0.38), Group B showed a more consistent decline in pain levels. At 15- and 30-minutes post-SAB, the differences were statistically significant (p = 0.04 and p = 0.03 respectively), suggesting that Group B experienced more effective analgesia during the early postoperative period."

Table 15: VAS rest during SAB within the randomized groups

	Group-A		Group-B		
VAS at Rest	**Mean**	**Std Dev**	**Mean**	**Std Dev**	**p-Value**
At the time of positioning	2.6	1.4	2.3	1.2	0.38
5 mins after SAB	2.4	1.3	1.9	1.1	0.12
15 minutes after SAB	2.2	1.2	1.6	1.0	0.04*
30 mins after SAB	2.1	1.1	1.4	0.9	0.03*

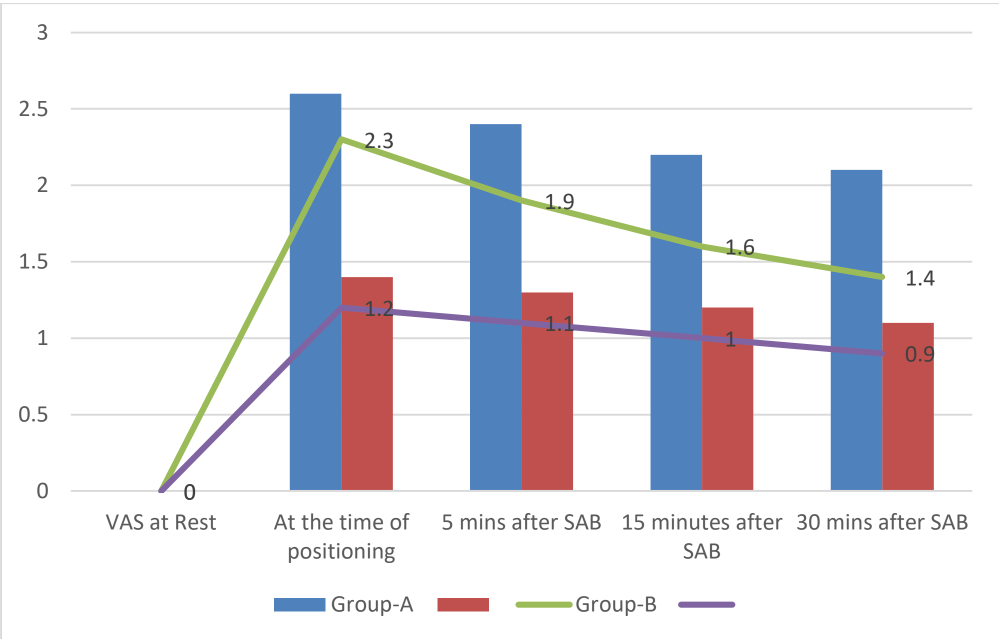

Figure 15: VAS-rest in SAB in the groups

VAS scores during movement were slightly higher in Group A at baseline and at the time of block, with both differences reaching statistical "significance (p = 0.03 and p = 0.04, respectively)." Subsequent time points showed no significant differences.

Table 16: VAS movement during PENG block within the randomized groups

	Group-A		Group-B		
VAS movement	**Mean**	**Std Dev**	**Mean**	**Std Dev**	**p-Value**
Baseline	4.9	1.7	4.3	1.8	0.03
At the time of Block	4.7	1.7	4.4	1.6	0.04
5 mins after block	3.8	1.4	4.1	1.5	0.51
10 minutes after block	4.7	1.8	4.5	1.5	0.73
15 mins after block	4.5	1.6	4.4	1.9	0.72
20 mins after block	5.1	1.9	4.2	1.5	0.11
6 hours after block	4.5	1.2	4.5	1.4	0.92
12 hours after block	4.3	1.3	4.5	1.5	0.63
24 hours after block	5.1	1.1	5.0	1.2	0.81

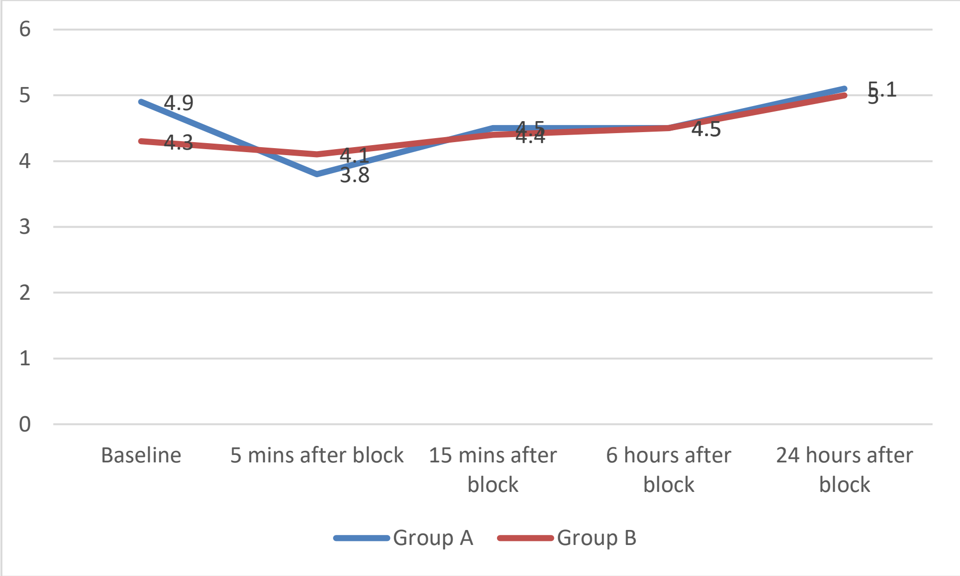

Figure 16: VAS movement during PENG block within groups

At the time of positioning, “Group-A had a mean of 4.8 ± 1.6, while Group-B had 4.2 ± 1.4, with a significant p-value of 0.004. Five minutes after spinal anesthesia (SAB), Group-A’s mean was 4.5 ± 1.5, and Group-B’s mean was 3.8 ± 1.3, with a p-value of 0.03, indicating statistical significance. However, at 15 minutes and 30 minutes after SAB, the p-values were 0.09 and 0.08, respectively, suggesting no statistically significant difference between the groups” at these times.

Table 17: VAS movement during SAB within the randomized groups

	Group-A		Group-B		
VAS with Movement	**Mean**	**Std Dev**	**Mean**	**Std Dev**	**p-Value**
At the time of positioning	4.8	1.6	4.2	1.4	0.004)
5 mins after SAB	4.5	1.5	3.8	1.3	0.03*
15 minutes after SAB	4.6	1.4	3.7	1.2	0.09
30 mins after SAB	4.5	1.3	3.7	1.1	0.08

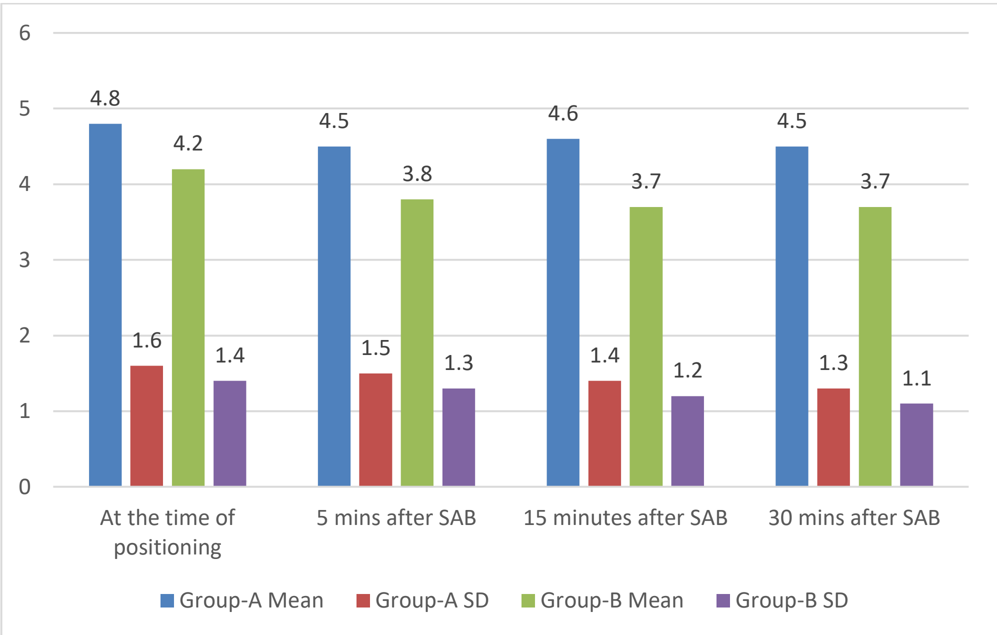

Figure 17: VAS movement in SAB within the groups

Group A required their first rescue analgesic later (mean 659.9 minutes) than Group B (mean 594.5 minutes), but the difference was not statistically significant (p = 0.265).

Table 18: Time of first rescue analgesic in the groups

Group		**Time of First rescue Analgesic**
Group A	Mean	659.9
	Std. Deviation	174.2
Group B	Mean	594.5
	Std. Deviation	157.1
Total	Mean	627.2
	Std. Deviation	167.4
p-value		0.265

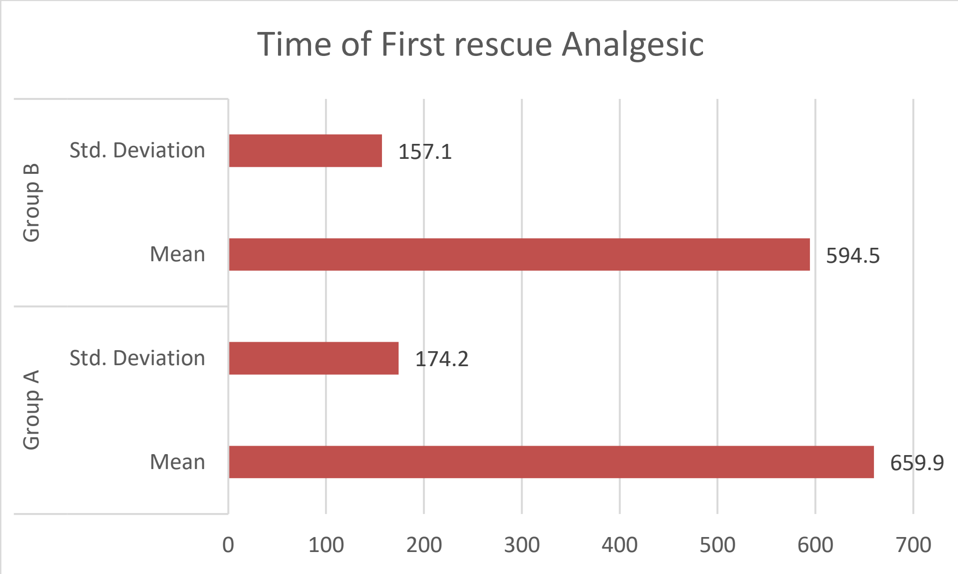

Figure 18: Time of first rescue analgesic in the groups

The mean dosage of Tramadol was identical in both groups at 97.9 mg. Diclofenac dosage was slightly higher in Group A (43.7 mg) compared to Group B (34.4 mg), but this difference was also not significant (p = 0.721).

Table 19: Dosage of drugs given in the both groups

Group		Tramadol dosage	Diclofenac dosage
Group A	Mean	97.9	43.7
	Std. Deviation	42.9	37.8
Group B	Mean	97.9	34.4
	Std. Deviation	37.5	38.2
Total	Mean	97.9	39.1
	Std. Deviation	39.9	37.9

p-value		1.0	0.721

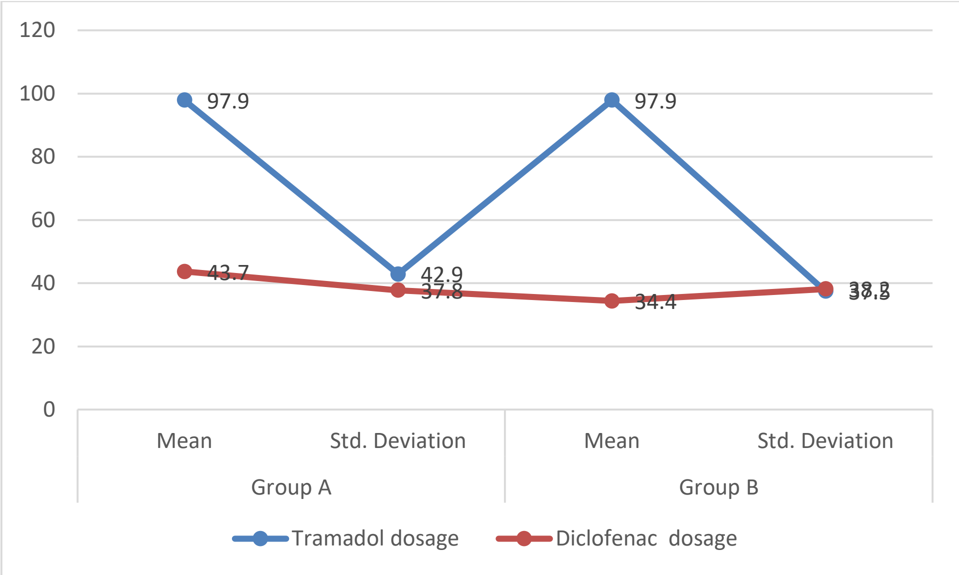

Figure 19: Dosage of various drugs given in the groups

DISCUSSION

The study cohort (n=48) demonstrated a male predominance (64.6%) and a majority aged >71 years (41.7%), aligning with epidemiological trends in hip fracture and arthroplasty populations, where older adults and males are overrepresented in traumatic hip injuries. Men had considerably higher ASA grades than women ($p < 0.001$), according to a retrospective examination of 7,827 patients from the "Swedish National Registry for Hip Fractures. This suggests that male patients had a higher burden of comorbidity. This demographic trend aligns with the higher frequency of comorbid diseases in males, which might exacerbate perioperative outcomes, and the higher incidence of hip fractures in older adults[47]

A larger burden of comorbidity is reflected in Group B's higher percentage of ASA Grade III patients (45.8% compared to Group A's 33.3%). Higher ASA scores were consistently linked to higher risks of postoperative complications, such as infections, cardiovascular events, hospital readmissions, and mortality, according to nationwide cohort research that included 170,193 hip fracture patients 60 years of age and older." In particular, hazard ratios (HRs) for 1-year mortality were 3.2 for men and 3.8 for women among patients with ASA scores of 4–5, as opposed to those with ASA scores of 1.[46]

Our study's surgical distribution—which included 27.1% dynamic hip screw (DHS) fixation, 31.3% hemiarthroplasty, and 41.7% total hip replacement (THR)—reflects current clinical procedures for treating hip fractures and degenerative joint conditions. Usually used only for stable intertrochanteric fractures, DHS fixation is linked to greater revision rates (10–30%) and postoperative discomfort because of mechanical issues. In comparison, arthroplasty (THR/hemiarthroplasty) entails more intrusive tissue disturbance but frequently yields better functional results. Group A's greater baseline movement-associated discomfort (4.9 ± 1.7 vs. 4.3 ± 1.8, p=0.03) might be due to variations in preoperative pathology or surgical damage.

The relative instability of internal fixation in the context of osteoporotic bone was highlighted by a meta-analysis involving 1,273 patients that found revision rates for hemiarthroplasty were 1.2% but those for dynamic hip screw (DHS) fixation were significantly higher at 14.4%. These results are especially pertinent to older adults, as poor bone health is a contributing factor to nonunion, hardware cut-out, and fixation failure. These mechanical issues are a primary cause of poor functional outcomes and often require revision surgery.[48]

According to a comprehensive study that included 71 studies including 5,973 individuals undergoing total hip arthroplasty, acute, severe postoperative pain usually subsides to mild levels (<4/10) 4–6 hours after surgery. Significant variation does exist, though, particularly among individuals who were frequently left out of these studies due to chronic pain or opioid dependence. Four different pain trajectories were found in a longitudinal investigation that examined acute movement-evoked postoperative pain intensity trajectories during the first five days following total hip arthroplasty. "Anxiety, cumulative morphine uses within 24 hours after surgery, and preoperative pain impairment" were significant predictors of pain trajectory membership.[49]

These results demonstrate the complex nature of postoperative pain and the necessity of thorough preoperative evaluations in order to maximize functional recovery and pain management. Lower Visual Analog Scale (VAS) scores at positioning (4.2 ± 1.4 vs. 4.8 ± 1.6, p=0.004) and five minutes after spinal anesthesia (SAB) (3.8 ± 1.3 vs. 4.5 ± 1.5, p=0.03) demonstrated Group B's superior pain control during SAB. This is consistent with previous research highlighting "the effectiveness of nerve blocks and multimodal analgesia in lowering acute pain during procedural positioning. Peripheral nerve blocks (PNBs) are one example" of a preemptive analgesic technique that has been shown to dramatically reduce pain during neuraxial anesthetic setting, improving patient comfort and cooperation.[48]

However, the phenomena of rebound pain after regional anesthetic resolves may be the reason for Group B's higher resting pain at 6 hours postoperatively (2.9 ± 1.2 vs. 2.2 ± 1.1, p=0.01). Rebound pain is defined as an abrupt increase in pain severity that usually happens 12 to 24 hours after a PNB's effects wear off. Patient satisfaction and recuperation may be impacted by this brief but substantial rise in pain. The use of multimodal analgesia to fill the gap as the block wears off, patient education of the potential for rebound pain, and the delivery of analgesics 1-2 hours before to the expected resolution of the nerve block are all examples of effective management techniques.

Additional research has examined the relative efficacy of various adjuvants in PENG blocks. Research comparing 0.2% ropivacaine with dexamethasone with fentanyl, for example, discovered that although both combinations produced similar acute postoperative analgesia, dexamethasone was more efficient than fentanyl at increasing the duration of analgesia. It has been demonstrated that multimodal analgesic techniques, which include non-opioid drugs like NSAIDs, acetaminophen, and adjuvants like gabapentin, lessen the need for opioids and the negative effects that come with them. Although the small sample size restricts the interpretability of this finding, the somewhat greater diclofenac usage in Group A (43.7 mg vs. 34.4 mg, p=0.721) might represent attempts to treat inflammation linked to more invasive operations like total hip replacement (THR).

According to pain trajectory data from a large systematic review of 5,973 patients undergoing total hip arthroplasty (THA) under general anesthesia, acute postoperative pain usually subsides within the first four hours after surgery to minor levels (<4/10 on the VAS). Optimized intraoperative analgesic techniques, such as the use of long-acting opioids, adjuncts like dexamethasone, and multimodal regimens incorporating acetaminophen, NSAIDs, and nerve blocks, are frequently credited with this early resolution.[13]

On the other hand, our cohort's VAS scores after 6 hours after surgery ranged from 2.2 to 2.9, suggesting that some patients had moderate, ongoing pain. Although spinal anesthesia (SAB) is beneficial for hemodynamic stability and decreased thromboembolic risk, it has a limited duration and may cause earlier rebound pain after its effects wear off. This discrepancy may be partially explained by variations in anesthesia modality. Furthermore, the window of optimal control may have passed if postoperative analgesia was not sufficiently preventive or multimodal, which would have contributed to the higher pain levels at the 6-hour mark[50]

Balasubramaniam et al. conducted a RCT to see the effects of ropivacaine by itself against ropivacaine plus dexamethasone in PENG blocks for hip surgery. According to the study, adding dexamethasone considerably increased the length of postoperative analgesia and decreased the need for rescue analgesics. In particular, the dexamethasone group consumed less rescue analgesia (tramadol) overall and “had a longer time to first rescue analgesic (445.0 ±17.4 minutes)” than the ropivacaine-only group (388.9±19.0 minutes). [46]

A “comparison of 0.2% ropivacaine with dexamethasone and fentanyl in PENG blocks” for proximal femur operations was carried out by Apte et al. in a different study. Although the initial postoperative analgesia from both combinations was similar, dexamethasone outperformed fentanyl in increasing the duration of analgesia. Dexamethasone group experienced no pain for a considerably longer period of time after surgery (655.3±35.5 minutes) than the fentanyl group (458.3±27.5 minutes).

A case series by Vergari et al. emphasized the use of dexmedetomidine in PENG blocks in conjunction with anesthesia for intramedullary femoral fixation in elderly patients who are at high risk. According to the study, PENG blocks combined with dexmedetomidine sedation successfully managed pain during the surgical and postoperative phases, allowing for safe and comfortable treatments without impairing cardiorespiratory function.[51]

Insights can also be gained from comparative research in other regional blocks. Yang et al., for example, “examined the effects of ropivacaine in combination with either dexmedetomidine or dexamethasone in thoracic paravertebral nerve blocks and erector spinae plane blocks for thoracoscopic lobectomy analgesia in a randomized controlled experiment.” There were no appreciable differences between the two adjuvants, but both increased the duration until the first postoperative remedial analgesia and decreased the use of perioperative analgesics.[52]

SUMMARY

1. Gender Distribution: Out of 48 participants, 64.6% were male and 35.4% female.

2. Age Distribution: The majority (41.7%) of participants were aged >71 years, followed by 37.5% aged 61–70 years.

3. ASA Grades Overall: ASA Grade III was most common (39.6%), followed by Grade I (33.3%) and Grade II (27.1%).

4. Type of Surgery: THR was the most frequent surgery (41.7%), followed by Hemiarthroplasty (31.3%) and DHS fixation (27.1%).

5. Age Distribution by Group: Group A had more participants aged 61–70 (50%), while Group B had more aged >71 (50%), with no significant difference ($p = 0.220$).

6. Gender by Group: Both groups had similar gender distribution (Group A: 66.7% male; Group B: 62.5% male; $p = 0.763$).

7. ASA Grade by Group: Group A had more Grade I (50%) while Group B had more Grade III (45.8%), showing a significant difference ($p = 0.041$).

8. Type of Surgery by Group: Group B had more THRs (50%) while Group A had more DHS fixations (37.5%), but this was not significant ($p = 0.248$).

9. Anthropometry: Mean age, weight, height, and BMI were similar in both groups with no significant differences ($p > 0.05$ for all).

10. Heart Rate during PENG Block: Heart rate remained stable and statistically similar across groups at all measured time points.

11. Heart Rate during SAB: No differences in heart rate were noted between groups during SAB (all $p > 0.05$).

12. Mean Arterial Pressure during PENG Block: MAP remained consistent across groups with no significant intergroup differences.

13. MAP during SAB: Mean arterial pressure was stable and comparable between

the two groups at all SAB intervals ($p > 0.05$).

14. VAS at Rest during PENG Block: Pain scores at rest were similar at all times except at 6 hours, where Group B reported significantly higher pain ($p = 0.01$).

15. VAS at Rest during SAB: Group B experienced better pain relief at 15 minutes ($p = 0.04$) and 30 minutes ($p = 0.03$) after SAB.

16. VAS with Movement during PENG Block: Group A had significantly higher pain at baseline ($p < 0.03$) and time of block ($p < 0.04$), but no significance thereafter.

17. VAS with Movement during SAB: Group B had significantly lower pain scores at positioning ($p = 0.004$) and 5 minutes post-SAB ($p = 0.03$); later differences were not significant.

18. Group A required analgesia later (659.9 min vs. 594.5 min), but the difference was not significant ($p = 0.265$).

19. Dosage of Analgesics: Both groups received the same mean dose of Tramadol (97.9 mg), and Diclofenac use was slightly higher in Group A but not significant ($p = 0.721$).

LIMITATIONS OF THE STUDY

The study was limited to 48 participants, which may affect the generalizability of the findings. Postoperative pain was assessed for only 24 hours; long-term outcomes were not evaluated. Results may not be representative of broader clinical practice settings. Effectiveness of the ultrasound-guided block may vary based on the skill and experience of the anesthesiologist.

Future studies should involve larger, multicenter populations to validate these findings. The research should include longer follow-up to assess chronic pain, mobility, and rehabilitation outcomes. They should include evaluate postoperative functional recovery, mobility scores, and patient satisfaction. Comparative studies with other adjuvants like clonidine or magnesium sulfate could provide broader insights. Standardized training for ultrasound-guided PENG blocks could help minimize operator-dependent variability.

CONCLUSION

This randomized controlled trial shows that combining ropivacaine with either dexmedetomidine or dexamethasone provide effective analgesia for hip surgery when used in an ultrasound-guided PENG block, with both combinations offering similar safety of our patients who received dexmedetomidine and hemodynamic stability. In comparison study demonstrated that patient who received dexmedetomidine had longer duration of postoperative analgesia, furthermore patient belonging to dexamethasone group had lesser pain score and have more complaint during positioning for spinal anaesthesia.

Although both regimens maintained comparable overall analgesic requirements and stability in vital indicators, the notable intergroup difference in ASA grades (more high-risk ASA III patients in Group B) may have affected pain outcomes. These results imply that either adjunct can be used successfully, with dexamethasone offering better early postoperative pain control and dexmedetomidine possibly providing slightly longer post-operative analgesia. To confirm these findings, account for baseline ASA differences, and investigate long-term recovery benefits, more extensive research is necessary.

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