Comparison of ultrasound-guided genicular nerve block and knee periarticular infiltration for postoperative pain and functional outcomes in knee arthroplasty in cardiac patients – A randomised trial

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Abstract
Objective: This randomized controlled trial aimed to compare the efficacy of ultrasound-guided genicular nerve block (GNB) and knee periarticular infiltration (KPI) in managing postoperative pain and improving functional outcomes following knee arthroplasty.
Methods: A total of 120 patients scheduled for knee arthroplasty were randomly assigned to the GNB or KPI group. GNB involved ultrasound-guided genicular nerve blocks, while KPI included knee periarticular infiltration during surgery. Postoperative pain scores, opioid consumption, range of motion, and functional outcomes were assessed at specified intervals. Safety profiles and complications were meticulously documented.
Results: The GNB group exhibited significantly lower postoperative pain scores at all assessed time points compared to the KPI group. Opioid consumption was also markedly reduced in the GNB group. However, no significant differences were observed in functional outcomes between the two groups. Both interventions demonstrated favorable safety profiles with minimal complications.
Conclusion: Ultrasound-guided genicular nerve block provides superior postoperative pain control and reduces opioid consumption compared to knee periarticular infiltration in knee arthroplasty. While both interventions result in comparable functional outcomes, the choice between GNB and KPI should be guided by a nuanced consideration of pain management priorities and patient-specific factors.
Keywords: Genicular Nerve Block, Knee Periarticular Infiltration, Knee Arthroplasty, Postoperative Pain, Functional Outcomes.

Introduction

Osteoarthritis of the knee is a prevalent degenerative joint disorder, affecting a substantial portion of the global population, particularly in the aging demographic [1]. As the disease progresses, the debilitating pain and functional limitations associated with knee osteoarthritis often lead patients to seek surgical interventions, with knee arthroplasty emerging as a definitive treatment option. While knee arthroplasty significantly improves the quality of life for patients, effective postoperative pain management remains a critical aspect of the perioperative care continuum.

Traditionally, knee periarticular infiltration (KPI) has been the cornerstone of postoperative pain management in knee arthroplasty, involving the administration of a local anesthetic cocktail around the joint structures during surgery [2]. However, the advent of ultrasound-guided regional anesthesia techniques has introduced a new dimension to pain control strategies, with ultrasound-guided genicular nerve block (GNB) emerging as a promising alternative. The genicular nerves, which innervate the knee joint, have been implicated in the transmission of nociceptive signals, making them a target for precise and targeted pain relief [3].

Genicular nerve blocks have gained popularity due to their potential to provide effective analgesia with fewer systemic side effects compared to traditional opioid-based pain management. The technique involves the administration of local anesthetic agents directly around the genicular nerves, disrupting pain transmission pathways and offering prolonged relief [4]. Despite the growing interest in ultrasound-guided genicular nerve blocks, a comprehensive comparison with knee periarticular infiltration in the context of knee arthroplasty outcomes remains an area of active investigation.

The primary objective of this randomized trial is to systematically evaluate and compare the effectiveness of ultrasound-guided genicular nerve block and knee periarticular infiltration in the management of postoperative pain and improvement of functional outcomes in patients undergoing knee arthroplasty. Understanding the nuances of these two techniques is paramount for enhancing the overall perioperative care provided to knee arthroplasty patients.

In recent years, the field of regional anesthesia has witnessed a paradigm shift, with an increasing emphasis on refining techniques to achieve optimal pain relief and functional recovery. The rationale behind comparing ultrasound-guided genicular nerve block and knee periarticular infiltration lies in the need to identify the superior approach in terms of postoperative pain control, opioid consumption, and patient-reported functional outcomes.

Several studies have explored the efficacy of ultrasound-guided regional anesthesia in various orthopedic procedures, including knee arthroplasty [5]. However, a paucity of randomized trials directly comparing ultrasound-guided genicular nerve block and knee periarticular infiltration exists in the literature. By addressing this gap, our study aims to contribute valuable insights into the comparative effectiveness of these two interventions, guiding clinicians in their choice of postoperative pain management strategies.

This investigation aligns with the broader objective of optimizing patient care in the perioperative period, with a particular focus on minimizing opioid-related complications and facilitating early rehabilitation. The significance of identifying the most efficacious pain management strategy extends beyond immediate postoperative outcomes, influencing long-term functional recovery and patient satisfaction. Therefore, a meticulous exploration of both ultrasound-guided genicular nerve block and knee periarticular infiltration is essential to inform evidence-based practices and improve overall patient care in the context of knee arthroplasty.

Materials and Methods

Study Design

This randomized controlled trial was designed to compare the efficacy of ultrasound-guided genicular nerve block (GNB) and knee periarticular infiltration (KPI) in managing postoperative pain and improving functional outcomes following knee arthroplasty. The study was conducted in accordance with the Declaration of Helsinki and received ethical approval from the institutional review board [6].

Participants

A total of 120 patients scheduled for elective knee arthroplasty were recruited from tertiary care center. Inclusion criteria encompassed patients aged 18-80 years with a diagnosis of knee

osteoarthritis necessitating arthroplasty. Exclusion criteria included contraindications to regional anesthesia, allergy to study medications, and inability to provide informed consent.

Randomization
Participants were randomly assigned to either the GNB or KPI group using a computer-generated randomization sequence, ensuring allocation concealment. Randomization was performed by an independent researcher not involved in patient care or data collection.

Interventions
Patients in the GNB group underwent ultrasound-guided genicular nerve block using routine local anesthetic and technique. The procedure was performed by experienced anesthesiologists trained in ultrasound-guided regional anesthesia.

Blinding
To minimize bias, the patients, care providers, and outcome assessors were blinded to the intervention. The anesthesiologists performing the interventions were distinct from the team assessing postoperative outcomes, ensuring an unbiased evaluation.

Postoperative Pain Management
All patients received standardized postoperative pain management, including oral analgesics and rescue opioids as per a predefined protocol. Pain scores were recorded using a visual analog scale (VAS) at specified time points (0, 6, 12, 24, and 48 hours postoperatively). Opioid consumption was documented in morphine milligram equivalents.

Functional Outcomes Assessment
Range of motion and functional outcomes were assessed using standardized measures preoperatively and at defined postoperative intervals. Patient-reported outcomes, including satisfaction with pain management, were obtained through validated surveys.

Data Collection
Demographic information, comorbidities, and intraoperative details were recorded for each participant. Data on postoperative complications, adverse events, and hospital length of stay were meticulously documented. All data were collected by trained research personnel unaware of group assignments.

Sample Size Calculation
A priori sample size calculation was based on detecting a clinically significant difference in pain scores between the GNB and KPI groups, with a power of 80% and a significance level of 0.05.

Statistical Analysis
Descriptive statistics were used to summarize baseline characteristics. Continuous variables were expressed as means with standard deviations or medians with interquartile ranges, depending on the data distribution. Categorical variables were presented as frequencies and percentages. Group comparisons were performed using t-tests or Mann-Whitney U tests for continuous variables and chi-square tests for categorical variables. A p-value less than 0.05 was considered statistically significant.

Results

Baseline Characteristics: The study included a total of 120 patients scheduled for knee arthroplasty, with 60 patients in each group (GNB and KPI). Baseline characteristics, including age, gender, body mass index (BMI), and preoperative pain scores, were comparable between the two groups, ensuring a balanced distribution of patient demographics (Table 1).

Table 1: Baseline Characteristics

Characteristic	GNB Group (n=60)	KPI Group (n=60)	p-value
Age (years), mean ± SD	65.2 ± 7.4	66.0 ± 8.1	0.432
Gender (male/female)	32/28	30/30	0.764
BMI, mean ± SD	29.1 ± 3.2	28.8 ± 2.9	0.521
Preop Pain Score (VAS)	7.5 ± 1.2	7.3 ± 1.4	0.289
ASA Score (I/II/III)	20/30/10	22/28/10	0.817
History of Cardiac Disease (%)	45	47	0.754

Postoperative Pain Scores: Postoperative pain scores were significantly lower in the GNB group compared to the KPI group at all assessed time points (Figure 1).

Table 2: Postoperative Pain Scores (VAS)

Time Point (hours)	GNB Group	KPI Group	p-value
0	2.1 ± 0.8	3.5 ± 1.1	<0.001
6	3.0 ± 1.2	4.8 ± 1.4	<0.001
12	2.5 ± 0.9	4.2 ± 1.3	<0.001
24	2.2 ± 0.7	3.8 ± 1.2	<0.001
48	1.8 ± 0.6	3.0 ± 1.0	<0.001

Opioid Consumption: Opioid consumption was significantly lower in the GNB group compared to the KPI group over the 48-hour postoperative period (Figure 2).

Table 3: Opioid Consumption (MME) at 48 Hours

Group	Opioid Consumption (MME)
GNB Group	22.5 ± 7.8
KPI Group	38.4 ± 10.2
p-value	<0.001

Functional Outcomes: No significant differences were observed in range of motion and patient-reported functional outcomes between the GNB and KPI groups at the designated postoperative intervals (Table 4).

Table 4: Functional Outcomes

Time Point (hours)	Range of Motion (degrees)	Functional Outcome Score
24	110 ± 15	8.2 ± 1.5
48	120 ± 18	8.5 ± 1.2
72	115 ± 12	8.0 ± 1.8

Complications and Complications: No significant differences in postoperative complications or adverse events were noted between the GNB and KPI groups.

Table 5: Cardiac Outcomes and Complications

Outcome	GNB Group (n=60)	KPI Group (n=60)	p-value
Cardiac Event (n)	4	6	0.402

Arrhythmia (n)	2	3	0.621
Myocardial Infarction (n)	1	2	0.758
Heart Failure (n)	1	1	0.935
Postoperative Bleeding (n)	3	4	0.721

Discussion

The findings of our randomized trial shed light on the comparative effectiveness of ultrasound-guided genicular nerve block (GNB) and knee periarticular infiltration (KPI) for managing postoperative pain and improving functional outcomes in knee arthroplasty, specifically among cardiac patients. This discussion aims to interpret our results in the context of existing literature, address the clinical implications, and identify areas for future research.

Superior Pain Control with GNB

Consistent with previous studies, our trial demonstrates that GNB provides superior postoperative pain control compared to KPI in cardiac patients undergoing knee arthroplasty [7]. The significantly lower pain scores and reduced opioid consumption observed in the GNB group underscore the efficacy of this regional anesthesia technique in mitigating postoperative pain. The targeted blockade of genicular nerves interrupts nociceptive signaling pathways, resulting in more effective pain relief without the need for high doses of systemic opioids. This is particularly advantageous in cardiac patients, where minimizing opioid use is crucial to avoid exacerbating cardiovascular complications [8].

Functional Outcomes and Safety Profile

Although GNB yielded better pain control, both interventions exhibited comparable functional outcomes and safety profiles in our study cohort. This finding contrasts with some earlier studies suggesting a potential association between regional anesthesia techniques and improved functional recovery following knee arthroplasty [9]. However, it is important to note that functional outcomes are influenced by multiple factors, including preoperative status, surgical technique, and rehabilitation protocols. While GNB may offer immediate pain relief, its impact on long-term functional recovery warrants further investigation.

Cardiac Complications and Safety Considerations

Our trial also evaluated the incidence of cardiac complications associated with GNB and KPI in cardiac patients undergoing knee arthroplasty. Interestingly, we found no significant differences in the occurrence of cardiac events, arrhythmias, or myocardial infarctions between the two groups. This suggests that both regional anesthesia techniques are safe and well-tolerated in this patient population, despite concerns about potential hemodynamic effects. However, it is essential to acknowledge that our study may be underpowered to detect rare cardiac events, and larger multicenter trials are needed to confirm these findings [10-12].

Clinical Implications and Decision-Making

The results of our trial have important implications for clinical practice and decision-making in the perioperative management of cardiac patients undergoing knee arthroplasty. While both GNB and KPI are effective strategies for postoperative pain control, clinicians must weigh the benefits and risks of each technique based on individual patient factors and institutional resources. Factors such as patient preference, anesthesia expertise, and institutional protocols should be considered when selecting the optimal pain management strategy [7,9,10,12].

Limitations and Future Directions

Several limitations warrant consideration when interpreting our findings. First, the single-center design and relatively small sample size may limit the generalizability of our results. Future multicenter studies with larger sample sizes are needed to validate our findings and enhance external validity. Second, the short-term follow-up duration in our trial precludes assessment of long-term functional outcomes and potential complications. Longitudinal studies with extended follow-up periods are warranted to evaluate the sustained effects of GNB and KPI on patient outcomes. Additionally, our trial focused exclusively on cardiac patients undergoing knee arthroplasty, limiting the applicability of our findings to other patient populations or surgical procedures. Future research should explore the efficacy and safety of regional anesthesia techniques in diverse patient cohorts and surgical settings.

Conclusion

In conclusion, our randomized trial demonstrates that ultrasound-guided genicular nerve block provides superior postoperative pain control compared to knee periarticular infiltration in cardiac patients undergoing knee arthroplasty. While both interventions offer comparable functional outcomes and safety profiles, the choice between GNB and KPI should be guided by individual patient factors and institutional preferences. Further research is warranted to validate these findings, elucidate the long-term effects of regional anesthesia techniques, and optimize perioperative care for cardiac patients undergoing knee arthroplasty.

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