ORIGINAL RESEARCH

Comparative Study of Lidocaine vs. Ropivacaine in Peribulbar Block for Cataract Surgery: An Ophthalmic Pharmacology Perspective

[1]Dr. Aditi Khare, [2]Dr. Pandav Krunal Damjibhai, [3]Dr. Prathmesh Pravin Parekh, [4]Dr. Aniket Jitendrabhai Patel

[1]Assistant Professor, Department of Anaesthesia, Lord Buddha Koshi Medical College and Hospital, Saharsa, Bihar, India
[2]Assistant Professor, Department of Anaesthesia, ICARE Institute of Medical Sciences and Research & Dr Bidhan Chandra Roy Hospital, Haldia, West Bengal, India
[3]Assistant Professor, Department of Pharmacology, ICARE Institute of Medical Sciences and Research & Dr Bidhan Chandra Roy Hospital, Haldia, West Bengal, India
[4]Assistant Professor, Department of Ophthalmology, KM Medical College and Hospital, Mathura, UP, India

Corresponding Author
Dr. Aniket Jitendrabhai Patel
Assistant Professor, Department of Ophthalmology, KM Medical College and Hospital, Mathura, UP, India

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ABSTRACT

Aim: The aim of this study was to compare the efficacy and safety of lidocaine and ropivacaine for peribulbar block in cataract surgery, evaluating key parameters such as the onset and duration of anesthesia and akinesia, intraoperative analgesia, the need for supplemental injection, and complications. **Materials and Methods:** This prospective, randomized, comparative study was conducted at a tertiary care hospital. A total of 100 patients scheduled for elective cataract surgery were randomly assigned into two groups: Group L (Lidocaine) and Group R (Ropivacaine). Both groups received a peribulbar block using their respective anesthetics with hyaluronidase. The primary outcomes assessed were the onset and duration of anesthesia and akinesia, intraoperative analgesia, need for supplemental injections, and complications. **Results:** The results showed that Group L (Lidocaine) had a significantly faster onset of both anesthesia (2.8 ± 0.5 minutes) and akinesia (3.2 ± 0.7 minutes) compared to Group R (Ropivacaine) (3.5 ± 0.6 minutes and 4.1 ± 0.8 minutes, respectively, $p < 0.001$). However, Group R demonstrated a significantly longer duration of both akinesia (3.2 ± 0.6 hours) and analgesia (3.6 ± 0.7 hours), as well as a lower need for supplemental injections (4% vs. 18%, $p = 0.02$). Intraoperative analgesia was also better in Group R, with 90% of patients reporting no pain compared to 68% in Group L. The complication rates were low and similar between the two groups. **Conclusion:** Both lidocaine and ropivacaine were effective for peribulbar anesthesia in cataract surgery, with lidocaine providing faster onset and ropivacaine offering longer duration and better patient comfort. The choice between the two agents depends on the specific needs of the surgery and patient. Ropivacaine may be particularly advantageous in longer surgeries or those requiring extended postoperative pain control. Further research is necessary to evaluate the long-term outcomes and optimize anesthetic protocols in ophthalmic surgeries.

Keywords: Lidocaine, Ropivacaine, Peribulbar block, Cataract surgery, Ophthalmic anesthesia.

INTRODUCTION

Cataract surgery is one of the most commonly performed ophthalmic procedures worldwide, offering significant visual rehabilitation for patients affected by lens opacification. With the continuous evolution of surgical techniques, patient safety and comfort remain paramount, particularly regarding anesthesia. Regional anesthesia, specifically peribulbar block, has become a cornerstone in ocular surgery due to its effectiveness in achieving akinesia and anesthesia while minimizing systemic complications. The choice of anesthetic agent plays a critical role in the success of the block, influencing both intraoperative conditions and postoperative recovery.[1]

Among the wide array of local anesthetics available, lidocaine and ropivacaine are frequently considered for peribulbar anesthesia. Each agent presents a unique pharmacological profile, with implications for onset time, duration of action, potency, and safety. Understanding the differences between these two

agents is essential for ophthalmologists, anesthesiologists, and surgical teams aiming to tailor anesthetic protocols to individual patient needs, surgical requirements, and institutional preferences.[2]

Lidocaine is one of the oldest and most widely used local anesthetics in clinical practice. It is valued for its rapid onset of action and moderate duration, making it suitable for a variety of minor and intermediate procedures. In ophthalmology, lidocaine has traditionally served as a reliable agent for peribulbar blocks, providing quick anesthesia and acceptable muscle akinesia. However, its relatively short duration may necessitate supplementation during longer procedures and may be associated with increased postoperative discomfort if not carefully managed.[3]

On the other hand, ropivacaine, a newer amide-type local anesthetic, was developed with a focus on reducing cardiovascular and central nervous system toxicity compared to older agents such as bupivacaine. It has a slightly slower onset than lidocaine but offers a longer duration of sensory and motor blockade, which can be advantageous in extended surgical procedures or in situations where prolonged postoperative analgesia is desirable. Additionally, ropivacaine is thought to have a better safety profile, particularly in elderly populations and patients with comorbidities, making it an attractive option in the ophthalmic setting where patients are often older and medically complex.[4]

The clinical decision between using lidocaine or ropivacaine involves more than just comparing onset and duration. Factors such as tissue penetration, diffusion properties, pKa, protein binding, and vasodilatory effects all influence how these drugs perform in the confined and sensitive orbital environment. Moreover, the need for ocular akinesia without excessive intraocular pressure, a critical requirement in cataract surgery, necessitates a balanced pharmacologic approach. This balance is often modulated by combining local anesthetics or adjusting dosages, which further complicates direct comparisons and calls for systematic evaluation.[5]

From a pharmacological standpoint, both lidocaine and ropivacaine interact with sodium channels to block nerve conduction, but they differ in their lipid solubility, stereochemistry, and systemic distribution, leading to distinct clinical outcomes. Ropivacaine is the pure S-enantiomer, which is associated with reduced neurotoxicity and cardiotoxicity compared to racemic mixtures of other anesthetics. Lidocaine, while less selective, has established efficacy and a favorable track record, which supports its ongoing use in many surgical contexts. These fundamental differences raise important questions regarding their relative performance in peribulbar blocks specifically for cataract procedures, where precision and patient stability are crucial.[6]

Additionally, in the modern context of enhanced recovery protocols and patient-centered care, the anesthetic choice affects not only surgical workflow but also postoperative experience. Factors such as pain control, time to visual recovery, patient satisfaction, and the incidence of complications like chemosis, subconjunctival hemorrhage, or ocular motility disturbances are all impacted by the pharmacodynamics of the anesthetic used. These patient-centric outcomes are becoming increasingly relevant in evaluating the quality of ophthalmic care.

As healthcare systems strive for cost-effectiveness without compromising quality, comparing agents like lidocaine and ropivacaine also entails considering their economic implications. Lidocaine is generally more affordable and readily available, whereas ropivacaine, despite being more expensive, might offer value in terms of reduced need for supplementary anesthesia or faster recovery times. These considerations are especially pertinent in high-volume cataract centers where cumulative effects of drug choices can influence overall efficiency and resource utilization.[7]

This comparative study aims to systematically evaluate lidocaine and ropivacaine when used in peribulbar blocks for cataract surgery, focusing on key parameters such as onset time, duration of anesthesia and akinesia, intraoperative conditions, safety profiles, and patient outcomes. By approaching this analysis from an ophthalmic pharmacology perspective, the study seeks to clarify not only which agent performs better in a clinical sense but also why these differences arise based on their underlying pharmacological characteristics. The findings of this research have the potential to inform best practices, guide anesthetic selection, and enhance the overall quality of care in ophthalmic surgery.

MATERIALS AND METHODS

This prospective, randomized, comparative study was conducted at tertiary care hospital. The study was approved by the Institutional Ethics Committee, and informed written consent was obtained from all participants.A total of 100 patients scheduled for elective cataract surgery under peribulbar block were enrolled. Patients were selected based on the following inclusion and exclusion criteria:

- **Inclusion Criteria**
  - Age between 40 and 80 years
  - ASA physical status I or II
  - Willing to give informed consent
  - Undergoing unilateral cataract surgery

- **Exclusion Criteria**
  - Known allergy or hypersensitivity to local anesthetics
  - Bleeding disorders or anticoagulant therapy
  - Neurological or psychiatric disorders
  - Previous ocular surgery on the same eye
  - Infection or inflammation at the injection site

Randomization and Grouping

Patients were randomly allocated into two equal groups (n = 50 each) using a computer-generated random number table:

- **Group L (Lidocaine Group)**: Received 6 mL of 2% lidocaine + 1 mL hyaluronidase (150 IU) + 1 mL normal saline.
- **Group R (Ropivacaine Group)**: Received 6 mL of 0.75% ropivacaine + 1 mL hyaluronidase (150 IU) + 1 mL normal saline.

All solutions were prepared under sterile conditions by an anesthesiologist not involved in the clinical assessment, ensuring double blinding.

Methodology

The peribulbar block was administered with the patient in the supine position under strict aseptic precautions. A 26-gauge, 25-mm needle was used to deliver the anesthetic mixture into the inferotemporal and medial peribulbar space. Following the injection, gentle ocular massage was applied for five minutes to enhance the diffusion of the anesthetic agent and ensure effective blockade.

A blinded observer assessed several clinical parameters throughout the procedure. The onset of akinesia was recorded as the time from injection to the achievement of complete globe and lid immobility, evaluated using a 3-point scale across four ocular directions. The onset of anesthesia was noted as the time taken for the patient to report subjective loss of sensation in the conjunctiva and cornea. Intraoperative analgesia was assessed by the operating surgeon using a 4-point verbal rating scale to evaluate patient comfort during the surgery. The duration of both akinesia and analgesia was measured from the onset of the block until the return of ocular movement and the reappearance of pain sensation, respectively. The need for supplemental injection was documented if any patient required additional anesthetic administration. Finally, any complications occurring during or after the procedure, such as chemosis, hematoma, or systemic adverse effects, were carefully monitored and recorded.

Statistical Analysis

Data were analyzed using SPSS version 25.0. Continuous variables were expressed as mean ± standard deviation (SD) and compared using the unpaired t-test. Categorical data were compared using the Chi-square test or Fisher's exact test as appropriate. A p-value < 0.05 was considered statistically significant.

RESULTS

Table 1: Demographic Profile of Patients

The demographic characteristics of both groups were found to be statistically comparable, indicating effective randomization. The mean age in Group L (Lidocaine) was 63.2 ± 7.1 years, while in Group R (Ropivacaine) it was 62.6 ± 6.8 years (p = 0.58), showing no significant difference. The male-to-female ratio was similar in both groups, with Group L having 28 males and 22 females, and Group R having 27 males and 23 females (p = 0.84). The distribution of ASA physical status was also nearly identical, with 60% of patients in Group L and 58% in Group R classified as ASA Grade I, and 40% and 42% respectively as ASA Grade II (p = 0.82). These findings confirm that the baseline characteristics were well-matched between the two groups, ensuring that outcome differences are likely due to the intervention rather than confounding factors.

Table 2: Onset and Duration of Anesthesia and Akinesia

Group L demonstrated a significantly faster onset of both anesthesia and akinesia compared to Group R. The onset of akinesia in the lidocaine group was 3.2 ± 0.7 minutes, while in the ropivacaine group it was delayed to 4.1 ± 0.8 minutes (p< 0.001). Similarly, the onset of anesthesia was faster in Group L (2.8 ± 0.5 minutes) compared to Group R (3.5 ± 0.6 minutes), also with high statistical significance (p< 0.001). However, Ropivacaine showed a clear advantage in terms of the duration of action. The duration of akinesia was significantly longer in Group R (3.2 ± 0.6 hours) than in Group L (1.8 ± 0.4 hours), as was the duration of analgesia—3.6 ± 0.7 hours in Group R compared to 2.0 ± 0.5 hours in Group L (both p< 0.001). This indicates that while lidocaine acts faster, ropivacaine provides prolonged effect, which may be beneficial in longer surgeries or for extended postoperative pain control.

Table 3: Intraoperative Analgesia (Surgeon-Assessed Scale)

Assessment of intraoperative analgesia revealed that patients in Group R experienced better pain control during surgery. A greater percentage of patients in Group R (90%) reported no pain (score 0), compared to 68% in Group L. Mild discomfort (score 1) was reported by 26% of patients in Group L but only 10% in Group R. Moderate discomfort (score 2) was experienced by 3 patients (6%) in Group L, whereas no patients in Group R reported moderate or severe discomfort. These results suggest that ropivacaine not only provides longer analgesia but also ensures greater patient comfort during the surgical procedure.

Table 4: Requirement of Supplemental Injection

A significantly higher number of patients in Group L required supplemental anesthetic injections to achieve or maintain adequate anesthesia compared to Group R. Specifically, 9 patients (18%) in the lidocaine group required additional dosing, whereas only 2 patients (4%) in the ropivacaine group needed supplementation (p = 0.02). This reinforces the finding that ropivacaine provides a more reliable and sustained block, reducing the need for intraoperative top-ups.

Table 5: Complications Observed

The incidence of complications was low in both groups, with no major systemic side effects reported. Chemosis occurred in 3 patients (6%) in Group L and 2 patients (4%) in Group R. Subconjunctival hemorrhage was seen in 2 patients in Group L and 1 patient in Group R. Overall, the total complication rate was slightly higher in Group L (10%) than in Group R (6%), although this difference was not statistically significant. Importantly, neither group experienced serious complications, confirming that both lidocaine and ropivacaine are safe for use in peribulbar anesthesia.

Table 1: Demographic Profile of Patients

Parameter	Group L (n=50)	Group R (n=50)	*p*-value
Mean Age (years)	63.2 ± 7.1	62.6 ± 6.8	0.58
Male:Female Ratio	28:22	27:23	0.84
ASA Grade I (%)	60%	58%	0.82
ASA Grade II (%)	40%	42%	

Table 2: Onset and Duration of Anesthesia and Akinesia

Parameter	Group L (Lidocaine)	Group R (Ropivacaine)	*p*-value
Onset of Akinesia (min)	3.2 ± 0.7	4.1 ± 0.8	<0.001
Onset of Anesthesia (min)	2.8 ± 0.5	3.5 ± 0.6	<0.001
Duration of Akinesia (hours)	1.8 ± 0.4	3.2 ± 0.6	<0.001
Duration of Analgesia (hours)	2.0 ± 0.5	3.6 ± 0.7	<0.001

Table 3: Intraoperative Analgesia (Surgeon-Assessed Scale)

Analgesia Score (0–3)	Group L (n=50)	Group R (n=50)
0 – No pain	34 (68%)	45 (90%)
1 – Mild discomfort	13 (26%)	5 (10%)
2 – Moderate discomfort	3 (6%)	0 (0%)
3 – Severe pain	0 (0%)	0 (0%)

Table 4: Requirement of Supplemental Injection

Parameter	Group L (n=50)	Group R (n=50)	*p*-value
Supplemental Injection Needed	9 (18%)	2 (4%)	0.02

Table 5: Complications Observed

Complication Type	Group L (n=50)	Group R (n=50)
Chemosis	3 (6%)	2 (4%)
Subconjunctival Hemorrhage	2 (4%)	1 (2%)
Systemic Side Effects	0 (0%)	0 (0%)
Total Complications	5 (10%)	3 (6%)

DISCUSSION

The present study aimed to compare the efficacy and safety of lidocaine and ropivacaine in peribulbar block for cataract surgery. Both groups were well-matched in terms of demographic and baseline clinical characteristics, eliminating potential confounding factors. This aligns with the findings of Goyal et al. (2017), who also reported no statistically significant differences in baseline parameters such as age and ASA status in a similar patient cohort undergoing peribulbar anesthesia, suggesting that these variables have minimal influence on anesthetic outcomes when randomization is well-executed.[8]

In terms of onset, lidocaine exhibited a faster onset of both anesthesia and akinesia (2.8 ± 0.5 min and 3.2 ± 0.7 min, respectively) compared to ropivacaine (3.5 ± 0.6 min and 4.1 ± 0.8 min). These results are consistent with the study by Al Saeid et al. (2010), who observed a shorter onset time with lidocaine due to its lower pKa and higher lipid solubility, making it more rapidly diffusible through nerve membranes. In their study, lidocaine achieved ocular akinesia in 3.1 ± 0.9 minutes compared to 4.2 ± 1.1 minutes with ropivacaine, which closely parallels the findings of the current research.[9]

However, the duration of both akinesia and analgesia was significantly prolonged in the ropivacaine group (3.2 ± 0.6 hours and 3.6 ± 0.7 hours, respectively) compared to lidocaine (1.8 ± 0.4 hours and 2.0 ± 0.5 hours). These findings are supported by Badran et al. (2016), who demonstrated that ropivacaine, due to its intrinsic vasoconstrictive properties and lower systemic absorption, offers a more sustained block, lasting up to 3.5 hours post-injection in their peribulbar study. This prolonged effect is particularly advantageous for extended surgical procedures or when postoperative analgesia is desired.[10]

Regarding intraoperative comfort, our study showed that 90% of patients in the ropivacaine group experienced complete pain relief (score 0), significantly more than the 68% in the lidocaine group. This corresponds with results from Sinha et al. (2014), who found that ropivacaine provided better patient comfort during phacoemulsification surgery, as evidenced by reduced need for intraoperative sedation and fewer patient complaints of discomfort. Their study emphasized the role of ropivacaine in improving surgical conditions from the surgeon's perspective as well.[11]

The need for supplemental injections was significantly lower in the ropivacaine group (4%) compared to the lidocaine group (18%), indicating a more reliable and consistent anesthetic effect. This finding is in agreement with the observations of Kumar et al. (2015), who reported a supplemental injection rate of only 5% with ropivacaine compared to 20% with lidocaine in patients undergoing ocular surgery. The reduced need for top-ups not only enhances patient comfort but also minimizes interruptions during surgery.[12]

Complication rates were low and comparable between both groups, with minor occurrences of chemosis and subconjunctival hemorrhage, and no systemic side effects. These results echo those reported by Dole et al. (2019), who noted a similar safety profile for both drugs, with transient and minor ocular complications occurring in less than 10% of cases and no reported systemic adverse effects. Their study confirmed the overall safety of ropivacaine as an alternative to lidocaine in ophthalmic regional anesthesia.[13]

CONCLUSION

In conclusion, both lidocaine and ropivacaine demonstrate effective outcomes for peribulbar anesthesia in cataract surgery, with distinct pharmacological advantages. Lidocaine offers a rapid onset and moderate duration, making it suitable for shorter procedures, while ropivacaine provides a longer duration and better safety profile, particularly in terms of reduced toxicity. The choice between the two agents should be based on the specific needs of the patient and surgical scenario. Further research is needed to optimize protocols and fully evaluate the long-term effects of these anesthetics in ophthalmic surgery.

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