ORIGINAL RESEARCH

Comparative Study on the Efficacy of General vs. Local Anesthesia in Reducing Postoperative Inflammation in Ocular Surgeries

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

[1]Assistant Professor, Department of Ophthalmology, KM Medical College and Hospital, Mathura, UP, 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 Anaesthesia, Lord Buddha Koshi Medical College and Hospital, Saharsa, Bihar, India

Corresponding Author
Dr. Aditi Khare
Assistant Professor, Department of Anaesthesia, Lord Buddha Koshi Medical College and Hospital, Saharsa, Bihar, India

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ABSTRACT
Aim: The aim of this study was to compare the efficacy of general anesthesia (GA) versus local anesthesia (LA) in reducing postoperative inflammation in ocular surgeries, assessing both ocular and systemic inflammation outcomes. **Materials and Methods:** A prospective, comparative study was conducted at a tertiary care hospital with 100 patients undergoing elective ocular surgeries. Patients were randomly assigned to either GA (Group 1) or LA (Group 2). Preoperative assessments, intraoperative procedures, and standardized postoperative care were performed for all patients.Postoperative inflammation was measured using slit-lamp examinations, intraocular pressure (IOP), visual acuity, and systemic markers (C-reactive protein and erythrocyte sedimentation rate) at 1 day, 1 week, and 1 month post-surgery. **Results:** The GA group exhibited significantly lower postoperative inflammation scores at all follow-up points compared to the LA group ($p < 0.05$). Additionally, GA patients had better postoperative visual acuity at 1 month ($p = 0.039$) and lower levels of systemic inflammation as indicated by CRP and ESR ($p < 0.05$). **Conclusion:** General anesthesia was more effective in reducing postoperative inflammation and improving visual recovery compared to local anesthesia in ocular surgeries. While local anesthesia offers advantages such as fewer systemic complications and quicker recovery, GA may be more suitable for complex surgeries or patients requiring better inflammation control. Further studies are warranted to explore long-term outcomes.

Keywords: General anesthesia, local anesthesia, ocular surgery, postoperative inflammation, visual recovery

INTRODUCTION

Ocular surgeries, ranging from routine cataract operations to complex retinal procedures, have become increasingly common as medical advancements continue to improve surgical outcomes and patient recovery times. One critical aspect that significantly influences postoperative recovery is the management of inflammation, a natural response to tissue injury. Inflammation in the ocular region is particularly concerning due to the sensitive nature of the eye, where even mild swelling can impair vision, increase discomfort, and delay healing. The choice of anesthesia plays a pivotal role not only in the surgical experience but also in postoperative recovery, including the extent and duration of inflammation.[1]

Anesthesia in ocular surgeries typically falls into two broad categories: general anesthesia (GA) and local anesthesia (LA). General anesthesia, which induces a reversible loss of consciousness, is often employed in more invasive or complex procedures, especially when patient cooperation or surgical access is a concern. On the other hand, local anesthesia involves the targeted numbing of the surgical area while the patient remains conscious. Both forms of anesthesia have their advantages and limitations, and the choice between them is influenced by various factors, including the nature of the surgery, patient health, and surgeon preference.[2]

The question of which anesthesia modality is more effective in mitigating postoperative inflammation remains a subject of ongoing clinical investigation. Inflammation, characterized by redness, swelling, pain, and heat, is a physiological response that occurs as part of the body's healing process following injury. However, excessive or prolonged inflammation can lead to complications such as infection, scarring, and delayed wound healing. In the context of ocular surgery, inflammation can result in significant patient discomfort and, in some cases, long-term visual impairment. Thus, understanding how different anesthetic approaches influence the inflammatory response is crucial for optimizing postoperative outcomes.[3]

The effectiveness of general versus local anesthesia in reducing postoperative inflammation in ocular surgeries is complex and multifactorial. Each type of anesthesia impacts the body's inflammatory response through different mechanisms. General anesthesia, while offering the advantage of complete sedation and control over the patient's physiological state, can induce systemic effects such as changes in immune function and increased levels of stress hormones, which may exacerbate inflammation. Furthermore, the use of muscle relaxants, intubation, and mechanical ventilation during general anesthesia can contribute to increased postoperative inflammation through various pathways.[4]

In contrast, local anesthesia, by limiting the anesthetic effect to the surgical site, may present a more localized approach to reducing inflammation. Local anesthetics, such as lidocaine and bupivacaine, work by blocking nerve conduction, preventing pain at the site of surgery, and potentially reducing the inflammatory cascade triggered by tissue injury. Additionally, local anesthesia may limit the systemic effects that could otherwise contribute to inflammation. However, the effectiveness of local anesthesia in modulating inflammation also depends on various factors, such as the specific drug used, its concentration, and the method of administration. Some studies suggest that local anesthetics, in addition to their numbing effects, may have anti-inflammatory properties that could further aid in controlling postoperative swelling and discomfort.[5]

Despite the theoretical advantages of each anesthesia approach, empirical evidence comparing the efficacy of general versus local anesthesia in reducing postoperative inflammation in ocular surgeries remains limited and inconclusive. Many studies have focused on either the direct postoperative outcomes of anesthesia on pain or the broader context of recovery, with few specifically isolating inflammation as a primary endpoint. In addition, the effects of anesthesia may vary depending on the type of ocular surgery being performed. For example, cataract surgery, often performed under local anesthesia, may present different inflammatory outcomes compared to more invasive surgeries like vitrectomies or glaucoma procedures, where general anesthesia is more commonly used.[6,7]

MATERIALS AND METHODS

This was a prospective, comparative study aimed at evaluating the efficacy of general anesthesia (GA) versus local anesthesia (LA) in reducing postoperative inflammation in ocular surgeries. The study was conducted at tertiary care hospital following ethical guidelines and obtaining approval from the institutional review board (IRB) before commencement.A total of 100 patients were enrolled in the study, all of whom required ocular surgery, including cataract surgery, glaucoma surgery, or retinal procedures. Patients were randomly assigned to one of two groups: GA (Group 1) or LA (Group 2). Inclusion criteria included adults aged 18 to 80 years who were scheduled for elective ocular surgery. Exclusion criteria included patients with a history of chronic inflammatory eye diseases (e.g., uveitis), systemic diseases that could affect postoperative inflammation (e.g., uncontrolled diabetes), allergies to anesthetic agents, or those who underwent bilateral surgeries in a single sitting.

Group Allocation

- **Group 1 (General Anesthesia)**: 50 patients received general anesthesia for their ocular surgery. In this group, anesthesia was induced and maintained using standard protocols for GA, including the use of intravenous agents and inhalational agents (e.g., propofol, sevoflurane) under the supervision of an anesthesiologist.
- **Group 2 (Local Anesthesia)**: 50 patients underwent ocular surgery under local anesthesia. In this group, anesthesia was achieved by retrobulbar or peribulbar blocks using a combination of local anesthetics such as lidocaine or bupivacaine, with or without sedation, as determined by the clinical team.

Preoperative Assessment

All patients underwent a preoperative assessment that included a thorough medical history, physical examination, ocular examination (visual acuity, intraocular pressure, slit-lamp examination), and necessary investigations, such as blood tests, to ensure suitability for anesthesia.

Intraoperative Procedure

- In both groups, the surgical procedure was performed by the same experienced surgeon using standard surgical techniques for each type of ocular surgery. All surgeries were completed without complications, and the same postoperative care regimen was followed for all patients.

Postoperative Management

Postoperatively, all patients were monitored for any immediate complications related to anesthesia. Standard postoperative medications, including antibiotics and corticosteroids, were prescribed to reduce inflammation. Follow-up visits were scheduled at 1 day, 1 week, and 1 month after surgery.

Measurement of Inflammation

The primary outcome measure was the degree of postoperative inflammation, assessed at 1 day, 1 week, and 1 month post-surgery. Inflammation was quantified by measuring:

1. **Slit-lamp examination findings**: The degree of anterior chamber cells and flare, using a standardized grading system (e.g., 0 to 4 scale).
2. **Intraocular pressure (IOP)**: Measured using a non-contact tonometer at each follow-up visit.
3. **Postoperative visual acuity**: Any changes in visual acuity from baseline were recorded to assess any impact of inflammation on vision.
4. **Photographic documentation**: Ocular photographs were taken at each follow-up to visually assess the inflammation around the surgical site.

In addition to these, blood samples were drawn to measure systemic markers of inflammation, such as C-reactive protein (CRP) and erythrocyte sedimentation rate (ESR), at the time of surgery and during follow-up visits.

Statistical Analysis

Data were analyzed using SPSS version 25.0. Descriptive statistics were used to summarize the baseline characteristics of the patients in each group. Continuous variables were compared between groups using the independent t-test, while categorical variables were compared using the chi-square test. The level of statistical significance was set at $p < 0.05$. The difference in postoperative inflammation between the two anesthesia methods was the primary outcome.

RESULTS

Table 1: Patient Demographics

The demographic characteristics of patients in both groups were well-balanced, which ensured that the differences observed in postoperative outcomes could be attributed to the type of anesthesia rather than patient characteristics. Regarding age, the mean age of patients in the GA group was 58.2 ± 7.4 years, while in the LA group, it was 59.4 ± 6.8 years. The p-value of 0.520 indicates that there was no significant difference in the ages between the two groups, making it unlikely that age affected the results of the study. The gender distribution was also similar in both groups, with 30 males and 20 females in the GA group, and 28 males and 22 females in the LA group. With a p-value of 0.752, it can be concluded that gender was not a significant factor influencing the outcomes. Regarding the type of surgery, both groups had a similar distribution of surgical procedures. The GA group had 25 cataract surgeries, 15 glaucoma surgeries, and 10 retinal surgeries, while the LA group had 23 cataract surgeries, 16 glaucoma surgeries, and 11 retinal surgeries. The p-values for cataract (0.812), glaucoma (0.890), and retinal surgeries (0.852) show that the type of surgery was evenly distributed between the groups, ensuring that differences in inflammation were not due to the type of surgery.

Table 2: Slit-Lamp Examination Findings (Inflammation Grading)

Slit-lamp examination findings, which assessed anterior chamber cells and flare to determine the level of inflammation, showed significant differences between the GA and LA groups at all timepoints. On Day 1 post-surgery, the GA group had a mean inflammation score of 2.3 ± 0.6, while the LA group had a higher mean score of 2.8 ± 0.7, with a statistically significant p-value of 0.026. This suggests that patients in the GA group had less inflammation compared to those in the LA group on the first day after surgery. At 1 week post-surgery, the GA group's mean inflammation score was 1.6 ± 0.5, whereas the LA group had a mean score of 2.0 ± 0.6. The p-value of 0.049 indicates that the GA group continued to have significantly lower inflammation at this timepoint as well. By 1 month post-surgery, the difference in inflammation was still significant, with the GA group showing a mean inflammation score of 0.5 ± 0.3, compared to the LA group's 0.8 ± 0.4 (p-value = 0.012). These results indicate that GA consistently resulted in less postoperative inflammation compared to LA, with the difference remaining significant even one month after surgery.

Table 3: Intraocular Pressure (IOP) Postoperatively

Intraocular pressure (IOP) measurements were taken at three time points after surgery, and the results indicated that the GA group generally had lower IOP compared to the LA group. On Day 1 post-surgery, the GA group had a mean IOP of 16.3 ± 3.1 mmHg, while the LA group had a higher mean IOP of 17.8 ± 3.4 mmHg. The difference was statistically significant (p-value = 0.045), suggesting that GA resulted in lower IOP immediately following surgery. However, at 1 week post-surgery, the mean IOP in the GA group was 15.7 ± 2.8 mmHg, while the LA group had a mean IOP of 16.9 ± 3.2 mmHg (p-value = 0.066). This difference was not statistically significant, though it still indicated a trend towards lower IOP in the GA group. By 1 month post-surgery, the mean IOP in the GA group was 15.2 ± 2.5 mmHg, while the LA group had a mean of 16.3 ± 3.0 mmHg (p-value = 0.089). The p-value was not significant at this time point, suggesting that the difference in IOP between the groups diminished over time. Despite this, the initial reduction in IOP in the GA group supports the idea that GA may have a transient beneficial effect on IOP control postoperatively.

Table 4: Postoperative Visual Acuity

Postoperative visual acuity was measured at several time points to determine the impact of anesthesia type on recovery. Preoperatively, there was no significant difference in visual acuity between the two groups, with the GA group having a mean LogMAR score of 0.42 ± 0.18 and the LA group having 0.43 ± 0.19 (p-value = 0.725). At 1 week post-surgery, the GA group had a slightly better mean visual acuity (0.20 ± 0.12 LogMAR) compared to the LA group (0.26 ± 0.15 LogMAR), but the difference was not statistically significant (p-value = 0.089). By 1 month post-surgery, the GA group had significantly better visual acuity, with a mean LogMAR score of 0.08 ± 0.10, compared to the LA group's 0.14 ± 0.13 (p-value = 0.039). This indicates that patients in the GA group experienced faster visual recovery and better visual outcomes at the 1-month follow-up compared to the LA group, suggesting that GA may contribute to improved long-term visual recovery.

Table 5: Systemic Inflammatory Markers (CRP and ESR)

Systemic inflammatory markers, specifically C-reactive protein (CRP) and erythrocyte sedimentation rate (ESR), were measured at preoperative and postoperative time points to assess the overall inflammatory response. For CRP (mg/L), preoperative levels were similar between the two groups (GA: 4.5 ± 1.2, LA: 4.7 ± 1.4, p-value = 0.667). At 1 week post-surgery, the GA group showed a lower CRP level (3.2 ± 1.0) compared to the LA group (4.0 ± 1.3), with a significant p-value of 0.034. By 1 month, the GA group's CRP remained lower (1.0 ± 0.6) compared to the LA group (1.6 ± 0.7), with a p-value of 0.029, indicating that the GA group had a more favorable systemic inflammatory response. Regarding ESR (mm/hr), preoperative levels were similar between the two groups (GA: 18.3 ± 5.2, LA: 19.2 ± 4.8, p-value = 0.542). At 1 week post-surgery, the GA group had a slightly lower ESR (14.7 ± 4.1) compared to the LA group (16.8 ± 4.5), though this difference was not statistically significant (p-value = 0.062). By 1 month, the GA group's ESR was significantly lower (9.2 ± 3.3) compared to the LA group (12.1 ± 4.0), with a p-value of 0.045. These findings suggest that GA is associated with a lower systemic inflammatory response both at 1 week and 1 month after surgery, supporting the hypothesis that GA reduces postoperative inflammation more effectively than LA.

Table 1. Patient Demographics

Demographic Factor	Group 1 (GA)	Group 2 (LA)	p-value
Age (Mean ± SD)	58.2 ± 7.4	59.4 ± 6.8	0.520
Gender (M/F)	30/20	28/22	0.752
Type of Surgery			
Cataract Surgery	25	23	0.812
Glaucoma Surgery	15	16	0.890
Retinal Surgery	10	11	0.852

Table 2. Slit-Lamp Examination Findings (Inflammation Grading)

Timepoint	Group 1 (GA) - Mean ± SD	Group 2 (LA) - Mean ± SD	p-value
1 Day	2.3 ± 0.6	2.8 ± 0.7	0.026
1 Week	1.6 ± 0.5	2.0 ± 0.6	0.049
1 Month	0.5 ± 0.3	0.8 ± 0.4	0.012

Table 3. Intraocular Pressure (IOP) Postoperatively

Timepoint	Group 1 (GA) - Mean ± SD (mmHg)	Group 2 (LA) - Mean ± SD (mmHg)	p-value
1 Day	16.3 ± 3.1	17.8 ± 3.4	0.045
1 Week	15.7 ± 2.8	16.9 ± 3.2	0.066
1 Month	15.2 ± 2.5	16.3 ± 3.0	0.089

Table 4. Postoperative Visual Acuity

Timepoint	Group 1 (GA) - Mean Visual Acuity (LogMAR)	Group 2 (LA) - Mean Visual Acuity (LogMAR)	p-value
Preoperative	0.42 ± 0.18	0.43 ± 0.19	0.725
1 Week	0.20 ± 0.12	0.26 ± 0.15	0.089
1 Month	0.08 ± 0.10	0.14 ± 0.13	0.039

Table 5. Systemic Inflammatory Markers (CRP and ESR)

Inflammatory Marker	Group 1 (GA) - Mean ± SD	Group 2 (LA) - Mean ± SD	p-value
CRP (mg/L)			
Preoperative	4.5 ± 1.2	4.7 ± 1.4	0.667
1 Week	3.2 ± 1.0	4.0 ± 1.3	0.034
1 Month	1.0 ± 0.6	1.6 ± 0.7	0.029
ESR (mm/hr)			
Preoperative	18.3 ± 5.2	19.2 ± 4.8	0.542
1 Week	14.7 ± 4.1	16.8 ± 4.5	0.062
1 Month	9.2 ± 3.3	12.1 ± 4.0	0.045

DISCUSSION

The current study aimed to compare the efficacy of general anesthesia (GA) versus local anesthesia (LA) in reducing postoperative inflammation in ocular surgeries. In terms of demographic characteristics, the two groups in this study (GA and LA) were well-matched in terms of age, gender, and type of surgery, ensuring that the observed differences in outcomes were not due to these factors. Similar demographic distributions have been reported in previous research. For example, Singh et al. (2020) found no significant differences in age or gender between GA and LA groups undergoing cataract surgeries, further validating the randomization process in this study . Such consistency in demographics allows for more robust comparisons of anesthesia types across studies.[8]

In the slit-lamp examination findings, this study demonstrated that the GA group experienced less inflammation at all time points compared to the LA group. On Day 1, the GA group had a significantly lower inflammation score (2.3 ± 0.6) than the LA group (2.8 ± 0.7, p = 0.026). This result is consistent with previous studies, such as those by Lee et al. (2018), who reported that GA is associated with lower anterior chamber inflammation following cataract surgery.[9] Similarly, other studies have shown that the immediate postoperative period is characterized by a lower inflammatory response in patients receiving GA, which is believed to be due to the systemic anti-inflammatory effects of the drugs used in general anesthesia. In contrast, local anesthesia may trigger a more localized inflammatory response (Kumar et al., 2019).[10] The lower inflammation in the GA group persisted at 1 week and 1 month postoperatively, further supporting the long-term benefits of GA in reducing ocular inflammation (Tan et al., 2021).[11]

Regarding intraocular pressure (IOP), the GA group had lower IOP than the LA group on Day 1 (16.3 ± 3.1 vs. 17.8 ± 3.4 mmHg, p = 0.045), but this difference was not significant at later time points. The initial reduction in IOP with GA is consistent with findings by McAllister et al. (2017), who observed that general anesthesia reduced IOP more effectively than local anesthesia in patients undergoing glaucoma surgery . The transient nature of the difference in IOP found in this study may be due to the shorter-term effects of GA, such as reduced sympathetic tone and more controlled intraocular dynamics during the anesthetic period. However, the lack of significant differences in IOP at 1 week and 1 month suggests that both anesthesia types have comparable long-term effects on IOP.[12]

The study also assessed postoperative visual acuity, where the GA group demonstrated significantly better recovery at 1 month (0.08 ± 0.10 LogMAR vs. 0.14 ± 0.13 LogMAR, p = 0.039). This finding aligns with those of Patel et al. (2016), who reported that patients receiving GA for cataract surgery had better postoperative visual outcomes than those who underwent LA.[13] The improved visual acuity in the GA group may be related to reduced inflammation, which can impair visual recovery.

In terms of systemic inflammatory markers, both C-reactive protein (CRP) and erythrocyte sedimentation rate (ESR) were significantly lower in the GA group at 1 week and 1 month postoperatively. The GA group had a CRP of 3.2 ± 1.0 mg/L at 1 week compared to the LA group's 4.0 ± 1.3 mg/L (p = 0.034) and a lower ESR at 1 month (9.2 ± 3.3 mm/hr vs. 12.1 ± 4.0 mm/hr, p = 0.045). These findings are consistent with studies by Smith et al. (2019), who showed that GA leads to a more favorable systemic inflammatory response compared to LA.[14] The systemic anti-inflammatory effects of GA may contribute to the reduced CRP and ESR levels observed in this study. In contrast, LA may induce a higher inflammatory response due to the localized trauma and inflammatory mediators associated with injection and tissue manipulation (Zhang et al., 2020).[15]

While this study found GA to be superior in reducing postoperative inflammation and improving visual recovery, the results should be considered in the context of other surgical variables that could influence outcomes. For example, some studies have reported that the type of surgery (e.g., cataract vs. glaucoma surgery) could influence the inflammatory response (Knight et al., 2001). However, the current study found no significant differences in the type of surgery between the GA and LA groups, which supports the conclusion that anesthesia type was the key determinant in postoperative inflammation and recovery outcomes.

CONCLUSION

In conclusion, the comparative study on the efficacy of general versus local anesthesia in ocular surgeries suggests that both anesthetic techniques offer effective pain management, but with distinct advantages. Local anesthesia tends to be associated with a lower risk of systemic complications and quicker recovery times. However, general anesthesia may be preferred for more complex procedures or patients with higher anxiety levels. The choice of anesthesia should be tailored to the individual patient, considering factors such as the type of surgery, patient health, and surgeon preference. Further studies are needed to confirm long-term outcomes, especially in terms of postoperative inflammation and recovery.

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