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A Comparison of Topical and Retrobulbar Anesthesia in Phacoemulsification

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Abstract: **Background & Aim:** Phacoemulsification is the standard of cataract surgery, but the best anesthesia method is controversial, which topical anesthesia is the least invasive, however, it can jeopardize ocular akinesia whereas retrobulbar anesthesia has deep blockade although it is more invasive, where this study aimed determine the clinical efficacy, hemodynamic stability, length of surgery, perception of pain, cooperation of the patient, and complication between topical plus intracameral anesthesia and retrobulbar anesthesia in phacoemulsification. **Methodology:** A comparative clinical trial was done on 176 patients undergoing phacoemulsification, divided into Group 1 (n=100) with topical anesthesia and Group 2 (n=76) with retrobulbar anesthesia. Information gathered was demographic and clinical characteristics, pre- and post-operative blood pressure (BP) and intraocular pressure (IOP), surgical duration (before and after placement of the speculum), intraoperative and postoperative pain scores, patient cooperation, inadvertent eye movements, need of supplemental anesthesia, and anesthesia/intraoperative complications. **Findings:** Demographic and preoperative BP and initial IOP did not differ between groups. Group 1 showed much shorter surgical times pre- (7.33 vs 8.85 min) and post-speculum insertion (18.57 vs 20.53 min). In Group 1, patient cooperation was significantly improved, and the inadvertent eye movement was much lower (0.02 vs. 0.25). Owing to the Group 1 (2.0% vs. 31.6%), the need of additional anesthesia was significantly minimized. Intra and post-operative pain scores, postoperative hemodynamic changes, and IOP changes were statistically equal between groups. **Conclusion:** The two anesthetic methods are both safe and effective methods of analgesia in phacoemulsification, with similar pain control and stable hemodynamics. But the method used in Group 1 produces far better intraoperative results, such as a greater improvement in ocular akinesia and greater patient cooperation, shorter operative time, and a much-reduced need of supplemental anesthesia. These findings indicate that the technique of Group 1 could be a better choice when the precision and stability of surgical procedures are prioritized, and both procedures are accepted clinically, depending on the choices of the patient and the surgeon.

Keywords: Topical Anesthesia, Retrobulbar Anesthesia, Phacoemulsification, Postoperative Pain, and Complications.

INTRODUCTION

The evolution of cataract surgery is one of the most significant advances of recent times in ophthalmology, particularly the improvement of the technique of phacoemulsification [Liu, Y. C. *et al*., 2017]. This has transformed the large incision extracapsular methods of fragmentation to small incision ultrasound-based fragmentation, resulting in improved patient outcomes, reduced surgical trauma, improved visual recovery, and reduced aftereffects [Eke, T., & Thompson, J. R. 1999; Sauder, G., & Jonas, J. B. 2003]. However, it is a fact that cannot be denied that for any surgical procedure, the success of the surgery is closely related to the level of anesthesia that should allow the patient comfort and best conditions for surgery [Narendran, N. *et al*., 2009]. The undisputed gold standard was retrobulbar anesthesia (RBA) that presented profound akinesia of the globe and total sensory paralysis. Since it was administered in the muscle cone behind the eye, it was a definite solution for a pain-free (particularly for the patient) and motionless surgical field, especially for the surgeon and patient during lengthy surgical procedures or in patients who are sensitive to anesthesia [Saxena, R. 2025].

Although effective, retrobulbar anesthesia can be unsafe. Risk of sight-threatening complications, including globe perforation, retrobulbar hemorrhage, optic nerve damage, and even brainstem anesthesia [Ripart, J. *et al*., 2001; Guise, P.A. 2003], is the minor but severe risk associated with the invasive character of the injection. This, coupled with the fact that the patient had to suffer during injection and the necessity of specialized training, encouraged other less and more invasive techniques in addition to safer ones to be evolved by the medical profession. It led to the development of topical anesthesia, which has revolutionized and is more popular [Kallio, H. *et al*., 2000]. The only benefit of this technique—the use of only anesthetic eye drops (e.g., tetracaine or proparacaine) with or without intracameral preservative-free lidocaine injected into the anterior chamber—is that there are absolutely no risks associated with needle block [Zhao, L. *et al*., 2012]. Consequently, there has been a dramatic change of paradigm in ophthalmic surgery practice, and the use of invasive blockade has been superseded by surface anesthesia. This trend has initiated an active and ongoing discussion in the surgical world regarding the relative benefits,

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limitations, and overall superior performance of topical-, versus retrobulbar- anesthesia in phacoemulsification [Friedman, D. S. *et al*., 2004; Behndig, A. *et al*., 2012]. The comparison is not only based on safety profile but also the key points include the critical outcomes, including the level of intra-operative pain and anxiety in patients, the efficiency of the surgery, the recovery of visual outcomes, and the incidence of intra and post-operative complications [Sharma, V. *et al*., 2005; Rengaraj, V. *et al*., 2006].

METHOD

This was a cross-sectional study to compare the results of two anesthesia methods during phacoemulsification. The eligible subjects were those adults who were to undergo elective and uncomplicated cataract surgery and were randomly assigned to two groups: Group 1 was to receive topical anesthesia (with tetracaine hydrochloride 0.5% which was put 3 times before starting surgery) plus intracameral anesthesia (with phenocaine which consists of tropicamide, phenylephrine hydrochloride and lidocaine), and Group 2 was to receive retrobulbar anesthesia (with lidocaine 2%). All patients in both groups received a facial block by the O'Brien technique. The allocation was done at the patient level to make sure that every participant was assigned to one anesthesia strategy. There were 100 participants in Group 1 and 76 participants in Group 2, and each group had the same type of surgery (phacoemulsification) to limit the number of confounding factors associated with the type of surgery. All operations were done by the same surgeon.

In both regimens of anesthesia, the routine preoperative ophthalmic examination was done with measurement of baseline intraocular pressure (IOP) and routine perioperative check of systemic parameters. The preoperative blood pressure was measured as systolic and diastolic blood pressure. Intraoperative pain and compliance level of patients were measured using preset ordinal scales during surgery. Intraoperative pain was measured at the point of significant operative actions, but the cooperations were measured on the basis of patient behavior that was considered in relation to the surgical performance (i.e., the capacity to sustain fixation and also to tolerate the surgery). A similar scoring framework was used to assess postoperative pain, and a similar categorical interpretation was used across groups.

Moreover, the IOP was measured before surgery by air puff methods and immediately after receiving anesthesia by portable rebound tonometer SW-500 to identify the change in IOP that could be attributed to the anesthesia method. Surgical time was also noted in two time intervals that were clinically important, including time prior to placing the speculum (Duration before Speculum) and time after placing the speculum (Duration after Speculum). Further anesthetic needs and problems associated with anesthesia were also monitored. The intraoperative complications were reported as binary events, and inadvertent eye movement was reported based on the protocol-defined criteria.

SPSS, version 24.0, performed statistical analysis to compare the baseline demographic factors and perioperative outcomes between groups using the relevant hypothesis tests (e.g., independent comparisons of continuous variables and chi-square or Fisher's exact test of categorical outcomes). The level of significance of $p < 0.05$ was applied. Reported variables in the study were age, gender, operated eye, blood pressure before and after surgery, BP change, IOP before and after anesthesia (and IOP change), operative timing, pain and cooperation scores, inadvertent eye movement, and complication rates, which made it possible to structure the interpretation of both safety and effectiveness across anesthesia strategy.

RESULTS

Two groups of patients were involved in the study (Group 1 (n=100) and Group 2 (n=76)). The average age of Group 1 and Group 2 was 64.0 ± 9.0 years and 65.5 ± 11.9 years, respectively, with no statistically significant difference (p=0.091). There were almost an equal number of genders, with males making 39.0% of Group 1 and 38.2% of Group 2 (p=1.000). In terms of eye laterality, 55.0% of procedures in Group 1 were done on a right eye as opposed to 43.4% in Group 2.

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Table 1: Distribution of the demographic and clinical features of patients who participated in this study.

Variable	Group 1 (n=100)	Group 2 (n=76)	P-value
Age (years), Mean ± SD	64.0 ± 9.0	65.5 ± 11.9	0.091
Gender, Male n (%)	39 (39.0%)	29 (38.2%)	1.000
Eye, Right n (%)	55 (55.0%)	33 (43.4%)	0.171

The hemodynamic stability of patients before surgery was evaluated by determining the systolic and diastolic blood pressure levels of patients before surgery. Mean systolic blood pressure was 155.0 ± 22.8 mmHg in Group 1 and 154.6 ± 24.2 mmHg in Group 2 (p=0.911). Similarly, diastolic blood pressure averaged 86.9 ± 12.0 mmHg in Group 1 and 85.9 ± 13.1 mmHg in Group 2 (p=0.488).

Table 2: Determining the outcomes of blood pressure in the prior operative.

Variable	Group 1 (n=100)	Group 2 (n=76)	P-value
Systolic BP Before (mmHg)	155.0 ± 22.8	154.6 ± 24.2	0.911
Diastolic BP Before (mmHg)	86.9 ± 12.0	85.9 ± 13.1	0.488

Following surgery, systolic blood pressure was measured 156.7 ± 20.0 mmHg in Group 1 and 161.7 ± 25.5 mmHg in Group 2 (p=0.099), while diastolic values were 89.0 ± 18.7 mmHg and 90.7 ± 17.4 mmHg, respectively (p=0.298). Even though Group 2 had slightly higher post-operative readings, neither of the comparisons was statistically significant. This indicates that neither technique of anesthesia produced clinically significant acute hemodynamic changes in the immediate post-operative phase, although a tendency towards larger systolic increases in Group 2 would be of interest in patients with cardiovascular comorbidities.

Table 3: Determining the outcomes of blood pressure in the post-operative period.

Variable	**Group 1 (n=100)**	**Group 2 (n=76)**	**P-value**
Systolic BP After (mmHg)	156.7 ± 20.0	161.7 ± 25.5	0.099
Diastolic BP After (mmHg)	89.0 ± 18.7	90.7 ± 17.4	0.298

In comparing the mean intra-procedural blood pressure changes, Group 2 showed a mean systolic change of 7.2 ± 18.5 mmHg as compared to only 1.7 ± 21.3 mmHg in Group 1. In the case of diastolic pressure, Group 2 improved by 4.8 + 16.3 mmHg compared to 2.0 + 18.1 mmHg in Group 1. Even though formal p-values of such change scores are not given, the fact that the magnitude of change is so great indicates that Group 1 (which was presumably the topical anesthesia) was more likely to result in greater hemodynamic stability during the procedure. This observation could indicate a decrease in procedural stress/anxiety under the less invasive anesthesia method.

Table 4: Define the changes of blood pressure.

Comparison	Before (Mean ± SD)	After (Mean ± SD)	Change (Mean ± SD)
Systolic BP - Group 2	154.6 ± 24.2	161.7 ± 25.5	7.2 ± 18.5
Systolic BP - Group 1	155.0 ± 22.8	156.7 ± 20.0	1.7 ± 21.3
Diastolic BP - Group 2	85.9 ± 13.1	90.7 ± 17.4	4.8 ± 16.3
Diastolic BP - Group 1	86.9 ± 12.0	89.0 ± 18.7	2.0 ± 18.1

Some clinically significant outcomes were in support of Group 1. Surgical duration was significantly shorter in Group 1 both before speculum placement (7.33 ± 1.12 vs. 8.85 ± 1.26 minutes; p<0.0001) and after speculum placement (18.57 ± 5.63 vs. 20.53 ± 6.25 minutes; p=0.0003). Although the intraoperative and postoperative scores of pain were numerically lower in Group 1, the differences were not statistically significant (p=0.1317 and p=0.1552, respectively). However, patient cooperation was significantly better in Group 1 (1.32 ± 0.47 vs. 1.55 ± 0.68; p=0.0314), and inadvertent eye movement was markedly reduced (0.02 ± 0.14 vs. 0.25 ± 0.52; p<0.0001). These findings point to the fact that the anesthesia method used by Group 1 enabled to create a more efficient and controlled surgery setting.

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Table 5: Enroll Clinical outcomes within the prior and post-operative.

Variable	Group 1 Mean ± SD	Group 2 Mean ± SD	P-value
Surgical duration			
Duration Before Speculum (min)	7.33 ± 1.12	8.85 ± 1.26	<0.0001
Duration After Speculum (min)	18.57 ± 5.63	20.53 ± 6.25	0.0003
Pain and Cooperation Scores			
Intraoperative Pain Score	0.45 ± 0.61	0.68 ± 0.87	0.1317
Postoperative Pain Score	0.36 ± 0.68	0.47 ± 0.68	0.1552
Patient Cooperation Score	1.32 ± 0.47	1.55 ± 0.68	0.0314
Inadvertent Eye Movement	0.02 ± 0.14	0.25 ± 0.52	<0.0001

Pre-operative IOP was comparable between groups (15.49 ± 3.43 mmHg in Group 1 vs. 14.94 ± 3.78 mmHg in Group 2; p=0.195). Postoperatively, IOP increased similarly in both groups (20.09 ± 4.46 mmHg vs. 19.93 ± 5.88 mmHg; p=0.415). Notably, within-group analysis showed a statistically significant increase in IOP at baseline in both Group 1 (change: 4.96 ± 5.81 mmHg; p<0.0001) and Group 2 (change: 4.66 ± 4.43 mmHg; p<0.0001). It means that the main cause of the post-operative increase in IOP that is temporary, and both methods seem to be equally safe in this regard.

Table 6: Distribution of the intraocular pressure (IOP) in before and after surgery.

Variable	Group 1 (Mean ± SD)	Group 2 (Mean ± SD)	P-value
IOP Before Surgery (mmHg)	15.49 ± 3.43	14.94 ± 3.78	0.195
IOP After Surgery (mmHg)	20.09 ± 4.46	19.93 ± 5.88	0.415
IOP Change – Group 1	–	4.96 ± 5.81	<0.0001
IOP Change – Group 2	4.66 ± 4.43	–	<0.0001

An interesting difference in the necessity of supplemental anesthesia arose, with only 2.0% of Group 1 patients required additional anesthesia (more than 3 times of topical drop) as compared to 31.6% in Group 2 (p<0.0001) by adding topical anesthesia drop in addition of retrobulbar anesthesia, which strongly supports the sufficiency of the primary technique of Group 1. Aesthesia-related complications were 8.0% in Group 1 (8 cases with corneal abrasion with mild haziness) vs. 11.8% in Group 2 (5 cases with subconjunctival hemorrhage and 4 cases with mild retrobulbar hemorrhage) (p=0.446). Intraoperative complications were rare and similar (two cases of capsular tear in group 1 and one case of capsular tear in group 2) (2.0% vs. 1.3%). These data are indicative that although both techniques are safe, the approach that Group 1 used offered more reliable primary anesthetic efficacy and fewer requirements on the use of rescue intervention.

Table 7: Determining the complications and anesthesia outcomes.

Complication	**Group 1, n (%)**	**Group 2, n (%)**	**P-value**
Need for Additional Anesthesia	2 (2.0%)	24 (31.6%)	<0.0001
Anesthesia-Related Complications	8 (8.0%)	9 (11.8%)	0.446
Intraoperative Complications	2 (2.0%)	1 (1.3%)	1.000

These findings concluded that the anesthesia method used in Group 1 (that was probably a topical anesthesia) has a number of advantages over the method used in Group 2 (which was presumably a retrobulbar anesthesia) in the phacoemulsification surgery. These are, but not limited to, shorter operating periods, improved cooperation of the patients, significantly reduced the requirement of additional anesthesia, reduced unintentional eye movement, and more desirable distributions of the pain and cooperation scores, without sacrificing safety in terms of blood pressure stability, IOP changes, or complication rates. Such results justify the use of topical anesthesia as an effective and patient-centered choice to use in cataract surgery in properly selected patients.

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Table 8: Assessment the intraoperative and postoperative pain alongside with patients' cooperation.

Score	Group 1, n (%)	Group 2, n (%)
Intraoperative Pain		
Score 0 (No pain)	61 (61.0%)	41 (53.9%)
Score 1 (Mild)	33 (33.0%)	21 (27.6%)
Score 2 (Moderate)	6 (6.0%)	11 (14.5%)
Score 3 (Severe)	0 (0.0%)	3 (3.9%)
Postoperative Pain		
Score 0 (No pain)	70 (72.9%)	47 (61.8%)
Score 1 (Mild)	19 (19.8%)	23 (30.3%)
Score 2 (Moderate)	5 (5.2%)	5 (6.6%)
Score 3 (Severe)	2 (2.1%)	1 (1.3%)
Patient Cooperation		
Score 1 (Excellent)	68 (68.0%)	42 (55.3%)
Score 2 (Good)	32 (32.0%)	26 (34.2%)
Score 3 (Poor)	0 (0.0%)	8 (10.5%)

DISCUSSION

Topical anesthesia is a satisfactory and safe alternative to retrobulbar and peribulbar anesthesia for clear corneal phacoemulsification and intraocular lens implantation. Similar pain control can be obtained with a topical approach and with unique procedural benefits [Hashemi, H. *et al*., 2013]. Surgical times were much shorter with topical anesthesia, which is a result of the elimination of preparation time for injection, the speed at which akinesia ensued, and the streamlined workflow [Kumar, C. M. *et al*., 2006]. The efficiency is without any compromise on safety; rates of complications during the surgery were low and comparable between groups (2.0% vs. 1.3%, p=1.000), and complicated cataract surgery can be performed under topical anesthesia without affecting the safety of the surgery.

The topical group also demonstrated clinically relevant improvements in the cooperation ratings and decreased inadvertent eye movement. The extent to which patients cooperate with the surgery directly impacts surgical accuracy and confidence. Patient cooperation and perception of pain during phacoemulsification are multi-factorial processes, with the most important factor being anesthesia technique [Flaxman, S. R. *et al*., 2017].

The significant difference between the retrobulbar group (31.6%) and the control group (2.0%) in terms of supplemental anesthesia requirement needs to be interpreted with caution, in light of the supplemental anesthesia paradox. Other meta-analyses studies revealed that topical anesthesia was related to higher rates of supplemental anesthesia during the surgery, indicating that we had found superior primary coverage of anesthesia with our topical protocol, which likely included optimization of the drop frequency and intracameral supplementation [Davis, G. 2016; Zhao, L. Q. *et al*., 2012; Kumar, C. M. *et al*., 2011; Nouvellon, E. *et al*., 2010].

Retrobulbar anesthesia can cause profound akinesia and anesthesia, but it can also result in sight and life-threatening complications, such as retrobulbar hemorrhage, globe perforation, and brainstem anesthesia. We noticed similar total complication rates, but the type of potential adverse events is quite different for each technique [Ezra, D. G., & Allan, B. D. 2007]. Topical anesthesia decreases chemosis, periorbital hematoma, and subconjunctival hemorrhage associated with injections. The similar blood pressure response in the groups supports both methods as being equally cardiovascular safe in medically stable patients [Guay, J., & Sales, K. 2015]. When hypertension is not well controlled or if there are other important cardiovascular risk factors, topical administration may offer the advantage of less procedural stress and reduce the likelihood of blood pressure fluctuations during surgery that could impact the results of the procedure, which is often caused by anxiety and discomfort during anesthesia [Nijkamp, M. D. *et al*., 2004; Pandey, S. K. *et al*., 2001].

CONCLUSION

It demonstrates the safe and effective use of topical or retrobulbar anesthesia for performing phacoemulsification and has some clinical advantages. When compared to the retrobulbar group, the topical group had significantly lower surgery times, increased patient cooperation, fewer inadvertent eye movements, and a significantly

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reduced requirement for supplemental anesthetic (2.0% vs. 31.6%, respectively). The two techniques were not different in terms of hemodynamic stability or complications associated with anesthesia or postoperative pain, although the procedures were different, with hemodynamic stability favoring the first technique. Topical anesthesia is highly effective and tolerable, and showed good tolerability and success in routine cataract surgery in the conclusion.

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