SCIE DOI: 10.14744/scie.2022.50480
South. Clin. Ist. Euras. 2023;34(2):125-130

Original Article

Intraocular Pressure Changes in Prone Position and Affecting Factors

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Submitted: 11.06.2022
Revised: 14.09.2022
Accepted: 14.09.2022

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Keywords: Blood pressure; correlation; intraocular pressure; prone position; standard monitorization.

ABSTRACT

Objective: The incidence of perioperative vision loss after non-ocular surgeries range from 0.002% of all surgeries to 0.2% of heart and spine surgeries. The aim of the study was to examine the effect of prone position on intraocular pressure (IOP) and to evaluate other factors affecting IOP in the prone position.

Methods: Patients, aged between 18 and 65, years who underwent an elective surgical operation in prone position were included in this prospective study. After standard monitoring conditions and bispectral index score (BIS) monitoring, patients' IOP was recorded at preoperatively, after induction, position, 60th–120th and 180th min. Peak inspiratory pressure, desflurane amount in inhaled air, and end-tidal carbon dioxide monitoring were added after position. Student's t-test and correlation graphics were performed.

Results: The right and left IOP values decreased significantly after induction (respectively; p<0.001, p<0.001) and increased significantly at 60-120th and 180th min after position (in the right order; p=0.001, p<0.001). 0.001, p=0.003, p=0.01), (left order; p<0.001, p<0.001, p=0.02, p=0.01) were observed. When the correlation between IOP values and systolic blood pressure was evaluated; direct proportion at pre-operative time, inverse proportion post-induction and post-positioning, a plateau at the 60th min, direct proportion on the 120th and 180 min were observed. When the correlation between IOP values and diastolic blood pressure was evaluated; inverse proportion during pre-operative time and post-induction, and plateau post-induction, inverse proportion at minute 120 and direct proportion at minute 180 was observed.

Conclusion: Although the relationship between IOP and systolic and diastolic pressures is variable depending on measurement times, especially measurements with inverse proportions are particularly risky in terms of visual damage.

INTRODUCTION

Visual disturbances and vision loss development after interventions other than ocular surgery are rare, and the incidence varies between 0.001% and 1%. Postoperative vision loss, which may be partial or complete and unilateral or bilateral, is a serious complication of surgery in the prone position, and it occurs with greater frequency after spine, head and neck, and some orthopedic procedures.[1,2]

Although the pathogenesis of vision loss in patients has not been determined exactly, it is common in patients who undergo spinal surgery, and it is common in the postoperative period.[3] In the etiology, besides hypotension, blood loss, and anemia; inappropriate surgical positioning due to the surgery to be performed on the patient, and as a result, secondary development of central retinal arterycompression, venoclusion, and cerebralischemia are included.[4]

The fact that visual disturbances and vision loss occur not only after spinal surgery but also in patients who underwent proneposition surgery and in patients who underwent lower extremity surgery suggests that the application of the prone position has an effect on the development of this incident.[3] As all position-depending changes are the responsibility of the anesthesia practitioners, complications caused by intraocular pressure (IOP) changes are also a part of their liability.[5]

When the patient is in the prone position, IOP increases and the extent of this increase is related to the amount of time the patient is in the prone position. After only a few minutes in the prone position, IOP can increase significantly.[6] According to the American Academy of Ophthalmologynormal IOP is 10 to 21 mmHg. IOP s higher than 21 mmHg pose a risk for glaucoma, detached retina, and postoperative vision loss.[7]

In our study, we primarily aimed to IOP changes and to evaluate the relationship between the length of stay in the prone position and the IOP values. The presence of additional factors affecting IOP changes was also evaluated.

MATERIALS AND METHODS

A total of 60 patients, who did not have concomitant systemic diseases and were evaluated as ASA I-II in their pre-anesthesia examinations, were included. They were planned to be operated in the prone position by the surgical clinics in elective conditions, which predicted torture between 1 and 3 h. Patients under the age of 18 and over the age of 65, body mass index ≥35, patients with drug allergy, neurological or psychiatric disease, eye disease or ophthalmic operation other than refractive errors, drug and alcohol addiction, patients taking any medication known to alter IOP, patients who were expected to be difficult to intubate, who were urgent, and who did not want to participate in the study were excluded. The patients were evaluated preoperatively. The subjects who had suitable conditions for the study were informed about the study and their written informed consent was obtained. After the patients were taken to the operating room, standard monitoring (electrocardiography, noninvasive pressure, fingertip oxygen saturation, and temperature) and BIS monitoring were applied. In all cases, vascular access was established with a 16 G or 18 G intravenous cannula, and 0.9% NaCl infusion was started at a rate of 8 ml/kg/h.

The IOPs of the cases were measured with the "Tonopen XLaplanationtonometry" following the application of 2% proparacaine ophthalmic drops as local anesthesia 2-3 min before the measurements. After each measurement, 0.03% ofloxacin and ophthalmic drops containing fluoroquinolone group antibiotics were administered prophylactically. All patients were administered. Intravenous (IV) 1 mg/kg of lidocaine before the induction. After induction of anesthesia with propofol of 2 mg/kg IV, 1–1.5 µg/kg fentanyl and IV 0.6 mg/kg rocuronium was administered. When necessary, 0.1 mg/kg rocuronium was administered during the operation for muscle relaxation. Anesthesia was maintained by applying 4%–6% Desflurane in 50% air and 50% O_2. Ventilation parameters were adjusted to maintain end-tidal CO^2 at 35 to 40 mmHg, and peak inspiratory pressure (PIP) between 25 and 30 cm H_2O, PEEP was applied as 5 cmH_2O. Although the targeted tidal volume is achieved with this PEEP level; high PIP values were not observed. Heart rate and mean arterial pressure (MAP) were kept within ±20% of preoperative baseline values. During the maintenance of anesthesia, the BIS value was kept between 40 and 60. Repeated doses of muscle relaxants were used when necessary. 0.5 µg/kg fentanyl was administered to patients who developed hypertension and tachycardia after intubation (20% above baseline value and above 110 beats/min). Standard monitoring values, BIS values and IOP values were measured and recorded. After the patient was turned to prone position on the operating table, their heads were kept in a neutral position with a square prone hole pillow and it was confirmed that there was no external eye pressure. The head was positioned, paying attention that the neck flexion and extension were not more than 15°. Inspiratory pressure, desflurane amount in inhaled air (FiDes) and end tidal carbon dioxide ($etCO_2$) monitoring were added. IOP measurements were made immediately after the end of the positioning, at 60th min, at 120th and at 180th min.

Mean, standard deviation, median, lowest, highest, frequency and ratio values were used in the descriptive statistics of the data. The conformity of the variables to the normal distribution was examined using visual (histogram and Q-Q plot) and analytical methods (Kolmogorov–Smirnov test). Student's t-test was used in the normal distributed parametric data. p values below 0.05 were considered statistically significant. Analyzes were made with the SPSS 22.0 program.

Table 1. Demographic characteristics of patients and monitoring parameters

Variable	Mean±SD
Sex, n (%)	
Female	21 (35)
Male	39 (65)
Age	49.5±13.4
Weight (kg)	76.4±9.7
Height	170.1±13.3
SAP (preoperative) (mmHg)	123.08±10.98
DAP (preoperative) (mmHg)	72.51±11.41
MAP (preoperative) (mmHg)	89.78±9.86
HR (preoperative) (beats/min)	79.03±12.55
BIS (preoperative)	90.61±3.03
SpO_2 (preoperative) (%)	97.08±11.9

Values are presented as number of patients, frequency (%) or mean±SD; BIS: Bispectral index score; SD: Standard deviation; SAP: Systolic arterial pressure; DAP: Diastolic arterial pressure; MAP: Mean arterial pressure; HR: Heart rate.

Table 2. Comparison of patient's monitoring parameters over time

Variable	Baseline	Induction	Positioning	60th min	120th min	180th min
HR (beats/min)	79±16.207	74.4±16.636	74.3±15.595	68.7±10.229	68±12.141	71±12.355
SAP (mmHg)		123.0±12.147	108.2±9.492*	107.9±19.751	110.4±16.712	109.2±10.539
DAP (mmHg)		72.5±10.241	64.8±9.265*	66.2±8.456	70.1±10.274	64.9±10.537*
MAP (mmHg)		89.8±9.863	80.19±9.894	80.8±9.555	84.1±9.421	80.7±7.483
BIS	90.6±9.85	44.5±6.54*	46.9±8.06	48.9±5.32	49.0±4.03	50.9±4.89
SpO_2 (%)	97.08±0.99	99.2±0.77	99.2±0.625	99.35±0.58	99.4±0.56	99.13±0.
IOP-R (mmHg)	15.1±1.6*	13.23±1.74*	14.25±1.56*	15.8±1.5*	16.8±1.32*	17.73±0.703*
IOP-L (mmHg)	14.9±1.29*	13.0±1.35*	14.3±1.1*	15.8±1.2*	16.4±1.79*	17.5±1.35*
etCO2 (mmHg)			36.2±6.19	35.6±4.30	35.3±4.68	35.2±7.69
PIP (cmH_20)		18.3±3.29	18.5±2.30	18.9±4.30	18.8±4.1	
FiDES		4.5±2.48	5.7±1.1	5.9±0.2	5.9±0.3	

*Statistically different versus previous state (P<0.05). Values are presented as number of patients, frequency (%) or mean±SD; BIS: Bispectral index score; IOP: Intraoculer pressure; FiDES: Inspired concentration of desflurane; PIP: Peak ınspiratory pressure; HR: Heart rate; SAP: Systolic arterial pressure; DAP: Diastolic arterial pressure; MAP: Mean arterial pressure; IOP-R: Right IOP, IOP-L: Left IOP; SD: Standard deviation; etCO2: End tidal carbon dioxide.

RESULTS

During the study, 60 patients' (39 males and 21 females) data were evaluated. Thirteen patients (21.7%) were ASA I and 47 patients (78.3%) were ASA II. Other demographic characteristics of patients and monitoring parameters are given in Table 1.

IOP measurement values were recorded separately as right and left eyes. In male patients, preoperative right IOP (IOP-R) was 15.3±1.7 mmHg and left IOP (IOP-L) was 15.0±1.2 mmHg. In female patients, 14.8±1.5 mmHg and 14.6±1.2 mmHg were recorded. In both sexes; there was no statistical difference in IOP values of the right and left eyes (p=0.201 and p=0.193). When the IOP-R measurement values were examined; it was found that there was a significant decrease during anesthesia induction and a significant increase in subsequent follow-ups (p<0.001, p=0.002, p=0.001, p<0.001, p=0.003, p=0.01, respectively). When the IOPs-L were examined, a significant decrease with the induction of anesthesia and a significant increase in the following follow-up values were observed (p<0.001, p<0.001, p<0.001, p=0.02, and p=0.01, respectively) (Table 2).

Since there was no statistical difference between the two eyes in the correlation graph of systolic arterial pressure with the right and left eyes, only graphs with IOP-R were given (Figures 1 and 2). No statistically significant difference was observed in the parameters of BIS, SpO_2(%), $etCO_2$ (mmHg), PIP (cmH_20), FiDES followed during the surgery. The correlation between IOPs and systolic-diastolic arterial pressure measurements is shown in Figures 1 and 2.

When the relationship of instantaneous values between IOP and systolic blood pressure was evaluated, it was seen that it was directly proportional to preoperative IOP values and systolic blood pressure, inversely proportional after induction and after position, a plateau at 60th min, and directly proportional at 120th min and 180th min (Figure 1).

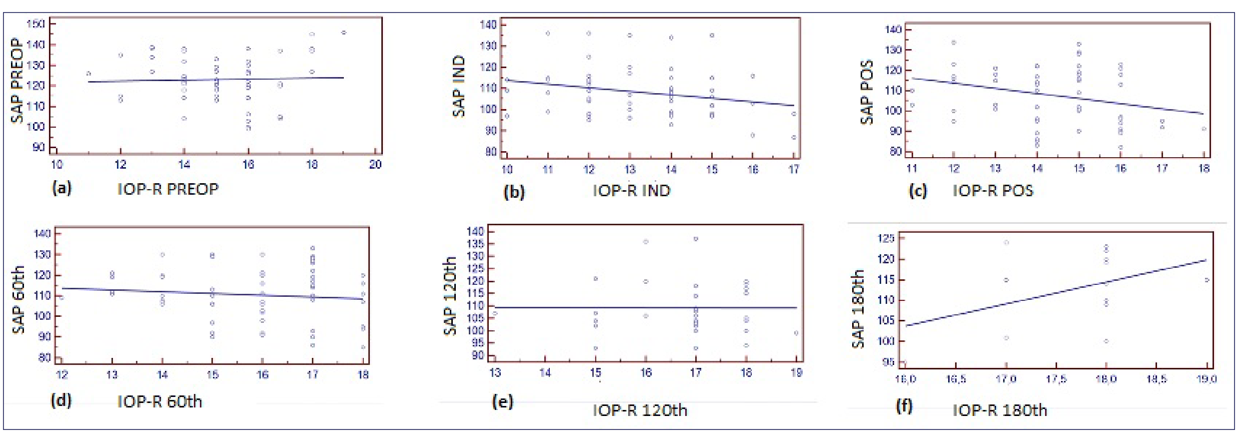

Figure 1. Correlation graphs of systolic arterial pressure (SAP) and right intraocular pressure (IOP-R) versus time. **(a)** SAP preop versus IOP-R preoperative, **(b)** SAP induction versus IOP-R induction, **(c)** SAP position versus IOP-R position, **(d)** SAP 60th min versus IOP-R 60th min.

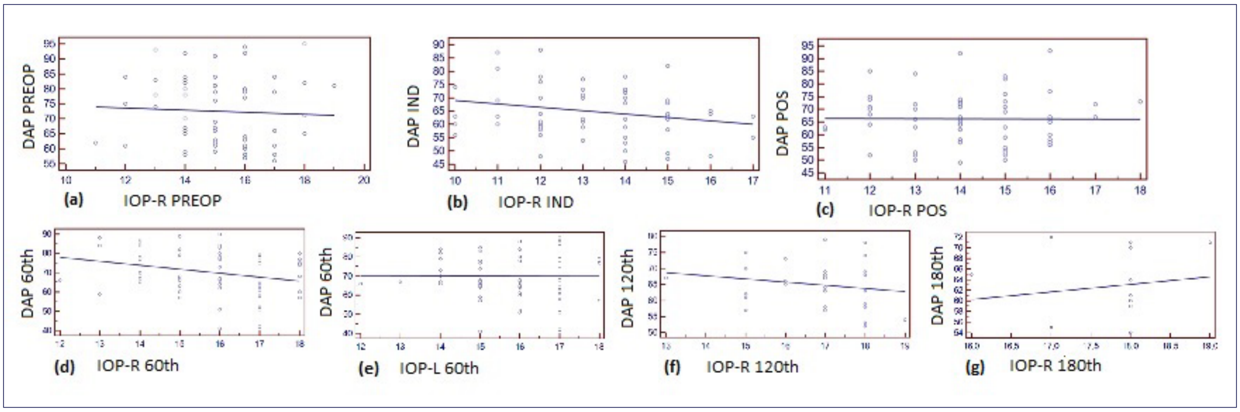

Figure 2. Correlation graphs of diastolic arterial pressure (DAP) and intraocular pressure (IOP) versus time. **(a)** DAP preop versus IOP-R preoperative, **(b)** DAP induction versus IOP-R induction, **(c)** DAP position versus IOP-R position, **(d)** DAP 60th min versus IOP-R 60th min, **(e)** DAP 60th min.

When the change in IOP and diastolic blood pressure (DAP) is examined; it was observed that preoperative and post-induction IOP values were inversely proportional to DAP, plateau after positioning. At the 60th min, a difference was found in the correlation graph of the right eye and the left eye (Figure 2d and e). At the 60th min, the IOP-R was inversely proportional to the diastolic pressure, while the IOP-L was in a plateau with the diastolic pressure. IOP-R and diastolic pressure were inversely proportional at 120th min measurements, and directly proportional at 180th min measurements.

DISCUSSION

Anesthesiologists are responsible for the positions given to the patient during surgery and the results of the physiological and pathological changes that these positions will bring. The prone position is among the surgical positions with more complications and difficulties.[5] General anesthesia is the preferred method of anesthesia because it provides the best protection of the airway in the prone position.[8,9] In a study, it was seen that general anesthesia is an independent risk factor for eye damage, and positions other than the supine position pose a risk for eye damage.[10]

Laryngoscopy and intubation increased hemodynamic responses and consequentially IOP, while hypnotic agents -except for ketamine- decreased IOP under general anesthesia.[11] Arslan et al.[12] observed a nonsignificant decrease in IOP after intubation and induction. In contrast, we observed a significant decrease in IOP.

Ocular perfusion pressure is determined by the difference between systemic blood pressure and IOP and is controlled by an autoregulation mechanism. Failure to maintain the perfusion pressure significantly leads to disruption of optic nerve autoregulation.[13] Unfortunately, there is no clinical method available to evaluate autoregulation in humans. Especially; hypotension, which may develop in surgical procedures performed in the prone position, impairs perfusion pressure and autoregulation, and poses a risk for vision loss.[14]

It is a known fact that decreased CO_2 levels, reduces IOP. Hvidberg et al.[15] in their study, determined that hypocapnia developed as a result of hyperventilation in patients under general anesthesia could provide 10–15% reduction in IOP, and suggested that the possible reason may be the volume changes in the choroidal veins. Moreover; similarly, they stated that hypercapnia also lead to an increase in IOP. In the study conducted by Hosking et al.[16] showing the effects of hypercapnic and hyperoxic conditions on IOP, glaucoma and healthy eyes were compared in awake volunteers. Although no increase in IOP was found in either group under hypercapnia conditions, it was shown that hyperoxic conditions decreased IOP in both groups.

In our study, when the $etCO_2$ and PIP, which started to be measured after position, were examined; it was determined that both values did not change significantly during general anesthesia and neither patient developed hypercarbia or hypocapnia. It was seen that fingertip SpO_2 values, which were followed up starting before induction, did not change significantly at all times and hypoxia did not develop in any of the patients.

Mechanical ventilation applied during general anesthesia causes an increase in IOP due to changes of venous return. In general terms, the PIP and positive end-expiratory pressure (PEEP) values are the main determinants of this interaction.[17] Johnson and Crittenden[18] reported that IOP s were not affected in patients who underwent 30 min of mechanical ventilation with PIP values of 7–15 cmH_2O, however, IOP s increased by 32.7% after 1 min of ventilation with high PIP values. Sohn et al.[19] observed that when ventilated with PEEP of 15 cmH_2O and above IOPs increased significantly, but they did not detect an increase in IOP in patients ventilated with 5 and 10 cmH_2O PEEP. In the study; it was stated that the effect of 15 cmH_2O PEEP application on IOPs could not be observed in short-term applications, but the IOPs increased significantly in patients who were applied mechanical ventilation for more than 24 h with the same values.[15] In our study; tidal volume was calculated according to ideal weight (5–8 ml/kg) and PEEP was applied as 5 cmH_2O. Although the targeted tidal volume is achieved with this PEEP level; high PIP values were not observed. In the light of the literature, we believe with these ventilation parameters the IOPs do not increase more than expected.

One of the parameters known to affect IOPs is the length of stay in the prone position.[20] In our study, the increase observed in the first 60 min was greater than the increment between min 60–120 and 120–180. We think that compensatory mechanisms that regulate IOP are activated. We think that further and comprehensive studies should be done on this subject.

Klein et al.[21] in their study comparing blood pressure and IOP values; found that increases in systolic and DAPs of 10 mmHg and above significantly increase IOP and reported that this could be a risk factor for the development of open-angle glaucoma. In the literature review study stated that the basis of the relationship between the increase in systemic blood pressure and the increase in IOP may be an autoregulation mechanism that develops to protect the ocular perfusion pressure, the relationship between them is multifactorial and has not been fully explained yet. They concluded that trying to provide aggressive blood pressure regulation can aggravate optic nerve damage, especially in patients with increased IOP.[22] In a study on primates under general anesthesia, they showed that optic nerve blood supply decreased significantly in the group with high IOP but low blood pressure; they showed that optic nerve blood supply did not change in the group with both high IOP and high blood pressure.[23] In accordance with the literature findings, it is known that hypotension and hypotensive anesthesia are important risk factors for postoperative vision loss and eye damage. When the study data were examined in line with this information, it can be suggested that the inverse ratio between systemic blood pressure and IOP that develops after induction and prone position (although both decrease significantly) starts to pose a risk in terms of optic nerve damage before the duration of prone position is prolonged. As a result of the effects of possible existing autoregulation mechanisms, this inverse ratio passed to the equalization phase at the 60th min, a concomitant increase was found between systolic pressure and IOP in 120th-180th min. Here, we think that the situation that needs further research is the relationship between diastolic pressures and IOP which maintains an inverse ratio at 60th and 120th min, and catches the direct proportion as systolic pressure does at 180th min.

Although there is no study in the literature, especially between diastolic pressure and IOP, in general studies conducted between blood pressures and IOP, systolic pressure was found to be more closely related to IOP than diastolic pressure and MAP.[15]

IOP elevation, which is one of the causes of postoperative vision loss, is not a subject that has been extensively studied. Although there is only one study on the subject, performed under general anesthesia in the prone position -with fewer patients-, the number of patients was one-third of our study. Although we obtained similar results with a higher number of patients. In addition, we concluded that systemic blood pressure changes may cause IOP changes and thus postoperative visual complications.

Our study has several limitations, one limitation is the fact that the frequency and the total number of IOP measurements were restricted to hourly measurements after the position and had to be terminated at the 180th min due to the fear of causing corneal trauma. Cheng et al. In their study, in which they measured changes in IOP up to the 5th h in 20 patients who underwent spinal surgery in the prone position, the rise in IOP over time was similar to our study.[24] Another limitation, is the relatively smaller study population.

Conclusion

As a result of this study, by being aware of possible complications related to vision in operations that require long-term prone position, long-term controlled hypotensive anesthesia, and in cases where the patient has risk factors, IOPs should be evaluated in these certain patient groups with hand tonometers, which are easy to use and non-invasive, complications could be reduced by taking the necessary precautions.

Ethics Committee Approval

This study approved by the Kartal Dr. Lutfi Kirdar City Hospital Clinical Research Ethics Committee (Date: 12.04.2017, Decision No: 2017/514/105/2).

Informed Consent

Retrospective study.

Peer-review

Externally peer-reviewed.

Authorship Contributions

Concept: E.H.U., M.K.B., M.A.Y., K.H.E., B.E.Ç.; Design: E.H.U., M.K.B., M.A.Y., K.H.E., B.E.Ç.; Supervision: M.A.Y., K.H.E., B.E.Ç.; Fundings: M.A.Y., K.H.E., B.E.Ç.; Materials: E.H.U., M.K.B., M.A.Y; Data: E.H.U., M.K.B., M.A.Y; Analysis: E.H.U., M.K.B., M.A.Y; Literature search: M.A.Y., E.H.U., M.K.B.; Writing: M.K.B., M.A.Y., K.H.E.; Critical revision: K.H.E., B.E.Ç., E.H.U.

Conflict of Interest

None declared.

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Prone Pozisyonda Göz İçi Basınç Değişiklikleri ve Etkileyen Faktörler

Amaç: Oküler olmayan ameliyatlardan sonra perioperatif görme kaybı insidansı, tüm ameliyatların %0.002'sinden kalp ve omurga ameliyatlarının %0.2'sine kadar değişmektedir. Çalışmanın amacı, yüzüstü pozisyonun göz içi basıncına olan etkisini incelemek ve yüz üstü pozsiyonda göz içi basıncını etkileyen diğer faktörleri değerlendirmektir.

Gereç ve Yöntem: Prospektif çalışmaya, 18-65 yaş arası, yüzüstü pozisyonda elektif cerrahi ameliyat geçiren hastalar alındı. Standart monitörizasyon koşulları ve bispektral indeks skoru (BİS) takibinden sonra, hastaların ameliyat öncesi, indüksiyon ve pozisyon sonrası, 60-120. ve 180. dakikalarda göz içi basınçları kaydedildi. Pozisyondan sonra tepe inspiratuvar basınç, solunan havadaki desfluran miktarı ve soluk sonu karbondioksit takibi eklendi. Student t testi ve korelasyon analizi uygulandı.

Bulgular: Sağ ve sol göz içi basıncı (GİB) değerinin indüksiyon sonrası anlamlı olarak azaldığı (sırasıyla; p<0.001, p <0.001) ve pozisyon sonrası, 60-120. ve 180. dakikalarda anlamlı olarak arttığı (sağ sırasıyla; p=0.001, p<0.001, p=0.003, p=0.01), (sol sırasıyla; p<0.001, p<0.001, p=0.02, p=0.01) gözlendi. GİB değerleri ile sistolik kan basıncı arasındaki korelasyona bakıldığında; preoperatif zamanda doğru orantı, indüksiyon sonrası ve pozisyon sonrası ters orantı, 60. dakikada plato ve 120. dk ve 180. dakikada doğru orantı bulundu. GİB ve diyastolik kan basıncı arasındaki korelasyon incelendiğinde; preoperatif ve indüksiyon sonrası ters orantı, pozisyon verildikten sonra plato, sonraki takiplerde 120. dakikada ters, 180. dakikada doğru orantı gözlendi.

Sonuç: Göz içi basınçları ile sistolik ve diyastolik basınçlar arasındaki ilişki ölçüm sürelerine bağlı olarak değişkenlik gösterse de özellikle ters orantılı ölçümler görme hasarı açısından özellikle risklidir.

Anahtar Sözcükler: Göz içi basıncı; kan basıncı; korelasyon; standart monitörizasyon; yüzüstü pozisyon.