Original Article

A study to evaluate ocular changes in patients undergoing spine surgery in the prone position

Kiranpreet Kaur, Neetu Khanduri, Sumit Sachdeva[1], Roop Singh[2], Mamta Bhardwaj, Manju Bala

Departments of Anaesthesiology and Critical Care, [1]Opthalmology and [2]Orthopaedics, Pt. B.D. Sharma PGIMS, Rohtak, Haryana, India

Abstract

Background and Aims: A present prospective study was conducted to evaluate ocular changes occurring in patients undergoing spine surgery in the prone position.

Material and Methods: A total of 44 patients of either sex, belonging to American society of Anaesthesiology I and II (aged 18-60 years) scheduled for elective spine surgery in prone position were enrolled in the study. Baseline IOP and MAP measurement were taken prior to induction. After induction of anaesthesia patients were intubated using flexo-metallic tube of appropriate size. IOP and MAP were recorded after induction of anaesthesia, following completion of surgery and immediately after turning the patient supine and 30 min following extubation. Blood loss and duration of surgery was also noted. The OPP was derived using the formula (OPP = MAP-IOP). Ophthalmic examination was also performed using direct and indirect ophthalmoscopy on the day prior to surgery and on first post-operative day to rule out anterior ischemic optic neuropathy (AION), posterior ischemic optic neuropathy (PION), and retinal ischemia.

Results: Mean IOP significantly increased (18.91 ± 3.56 mm Hg) ($P < 0.001$) at the end of surgery as compared to baseline value 12.85 ± 3.07 mm Hg. As a result mean OPP significantly reduced (75.12 ± 16.45) ($P = 0.0018$) at the end of the procedure.

Conclusion: In patient's undergoing spine surgery in the prone position, careful patient positioning with no extrinsic pressure on the eyes, minimal surgical time and blood loss, and prevention of intraoperative hypotension, should be ensured to prevent the IOP rise and a reduction in OPP which can further prevent post-operative visual disturbance.

Keywords: IOP changes, ocular perfusion pressure, ophthalmic complications, positioning problem, spine surgery

Introduction

Prone surgical positioning is commonly used position for procedures requiring the posterior approach to the spine.[1] The Prone position is associated with many important and potentially catastrophic complications.[2] Ocular complications being one of the important complication related to this position was first reported in 1948 by Slocum *et al.*[1,3-5]

The most common etiology and mechanism resulting in visual impairment is direct external pressure by head rest or other support on orbital content. Direct pressure, results in an increase in intraocular pressure (IOP), which further leads to retinal ischemia and finally visual loss. This mechanism has been named as "Hollen horst syndrome".[6] Another mechanism responsible for increase IOP causing post-operative visual loss in the absence of external compression on eyeball, include altered autoregulation leading to increase in intraocular blood volume. Any change in mean arterial pressure (MAP) results in inadequate oxygenation of the optic nerve, further causing ischemic damage. Perfusion pressure of the optic nerve is significantly decreased by increasing IOP. Ocular

Address for correspondence: Dr. Kiranpreet Kaur,
52/9 J, Medical campus, Rohtak - 124 001, Haryana, India.
E-mail: kiranpreet72@rediffmail.com

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perfusion pressure (OPP) can be calculated by subtracting IOP from mean arterial pressure (OPP = MAP-IOP).[7]

The change in IOP and OPP can result in other ophthalmic injuries like ischaemic optic neuropathy (ION), central retinal artery occlusion, and cortical blindness. Among these, ION is considered the most common cause of visual loss in 89% of the cases.[8] Based on the location, ischaemia ION is categorised anatomically into anterior ION and posterior ION. Anterior ION (AION) affects a junctional area of optic nerve, retina and the optic disc. Posterior ION (PION) occurs in the mid orbital region of the optic nerve and affects the retrobulbar or intracanalicular optic nerve. Both forms can be subdivided into arteritic and non-arteritic types. Arteritic ION is not seen as a surgical complication. Non-arteritic ION is most often caused by hypovolemia or anaemia.[6,9] Patients with PION report vision loss upon waking from general anaesthesia which is often bilateral and can result in complete blindness.[10,11] Besides the painless visual loss, visual field defects and sluggish pupils are other findings suggestive of ION.[12]

Central retinal artery occlusion (CRAO) is the second most commonly encountered cause of POVL after prone spine surgery.[12] Patients with CRAO most often suffer severe visual loss unilaterally. The fundoscopic examination reveals cherry red spots.[8] Cortical blindness results from decreased perfusion of visual cortex in the occipital lobe and may occur after spinal fusion or spinal deformity surgery. Severe hypotension, prolonged hypoxia or thromboembolism are the common etiological factors.[13]

The effect of prone position on spine surgery is known to cause various ophthalmic changes. Hence the present study was conducted to evaluate the ophthalmic changes in patients undergoing spine surgery in the prone position. The primary objective of the study was evaluate the changes in IOP and OPP. The secondary objective was to evaluate the change in MAP, to note surgical time, blood loss, and ophthalmic changes in patients undergoing spine surgery in the prone position.

Material and Methods

The prospective study was conducted in the department of anaesthesia in a teaching hospital after approval by the institutional ethics committee and following CTRI registration (CTRI/2019/01/017211). After calculating the sample size, the minimum required sample size at 5% level of significance and 95% power was obtained as 25 patients. A total of 51 patients reported during the study period, but 4 patients refused to participate in the study, and in 3 patients, the final readings could not be obtained. Hence, a total of 44 patients, aged between 18-60 years belonging to the American Society of Anesthesiologists (ASA) physical status I or II scheduled for elective spine surgery in prone position, were enrolled in the study.Informed consent from all the participants was obtained. Patients having a history of hypertension, eye infection/injury, previous eye surgery and Diabetes Mellitus were excluded from the study. In the operating room, intravenous line was established and standard monitors (non-invasive blood pressure, electrocardiography and pulse oximetry) were attached. After administration of topical antibiotic drops, baseline IOP measurement using a Schiotz tonometer was taken prior to induction. Simultaneously baseline MAP was also noted. Induction of anaesthesia was done with injection thiopentone 5 $mgkg^{-1}$, morphine 0.15 $mgkg^{-1}$ and vecuronium bromide 0.1 $mgkg^{-1}$ intravenously. Flexometallic tube of size, 7 for females and 8 for males was used to secure the airway. Balanced anaesthesia was continued with sevoflurane in concentration of 0.75 percent and N_2O and O_2 in the ratio of 66 to 33. Ventilation was controlled with a tidal volume of 8 $mlkg^{-1}$ and ventilatory rate was adjusted to maintain $EtCO_2$ value of 30-35 mm Hg. Airway pressures ranged between 18-22 cm H_2O in all the patients throughout the operative period.

IOP (I_1) and MAP (T_1) were recorded after induction of anaesthesia. Proper padding of eye was done before turning the patient prone. The Patient's head was kept in a neutral position on horse shoe shaped soft sponge headrest. After replacing the fluid for fasting period, intravenous ringer lactate 2 $mlkg^{-1}hr^{-1}$ was given as preoperative maintenance fluid and 6 $mlkg^{-1}hr^{-1}$ was supplemented for surgical fluid loss. Following completion of the surgery IOP (I_2) and MAP (T_2) was recorded immediately after turning the patient supine. Blood loss and duration of surgery was also noted. IOP (I_3) and MAP (T_3) were measured after 30 min of extubation in RR. Ocular perfusion pressure (OPP) was derived after IOP and MAP measurement using formula (OPP = MAP-IOP). Ophthalmic examination was also performed using direct and indirect ophthalmoscopy on the day prior to surgery and on first post-operative day to rule out AION, PION, and retinal ischemia. The Pupillary light reflex of both the eyes was evaluated. Fundoscopy was done to observe the optic nerve head oedema, flame shaped haemorrhage, for any evidence of AION, pupillary light reflex and optic nerve pallor for evidence of PION. A cherry red spot on the macula, pale or normal retina (retinal ischemia) was assessed to rule out central retinal artery occlusion. Qualitative assessment of retinal fiber thickness was also done in all four zones (nasal, temporal, superior, inferior).

Results

Forty-four patients were enrolled in the study. The mean age and weight of the patient was 37.36 ± 13.89 years and 60 ± 15 kg, respectively. Nineteen patients (43.2%) were females and 25 (56.8%) were males [Table 1]. The mean BMI of the patients were 24.43. Majority of patients were for fixation of spine following fracture of spine, few were posted for dissectomy following PIVD, spodylolisthesis, pott spine and caudaequina. The measurements from the right and left eyes were similar, so measurements of the right eye were used for statistical analysis. Mean IOP, MAP and OPP values are shown in Table 2. IOP and OPP trends are shown in Figures 1 and 2 respectively. Mean IOP was significantly increased (18.91 ± 3.56 mm Hg) ($P < 0.001$) at the end of surgery as compared to baseline values 12.85 ± 3.07 mm Hg. As a result mean OPP significantly reduced to 75.12 ± 16.45 mmHg ($P = 0.0018$) at the end of the procedure. The mean duration of surgery in the present study was found to be 122 ± 39.3 min. Average estimated blood loss in all the patients was 300-400 ml [Table 3]. Patients received average of 1.5 litres to maximum of 1.8 litres of fluid during the operative period. Ophthalmic changes and fundus findings are depicted in Table 4. On a qualitative assessment of retinal nerve fiber, we found thinning of the retinal nerve fiber layer in the inferior quadrant in 2 patients postoperatively, when compared to preoperative finding.

Statistical tests

Statistical analysis was performed using the SPSS statistical package (version 17.0; SPSS Inc., Chicago, IL, USA). Continuous variables are presented as mean ± SD, and categorical variables are presented as absolute numbers and percentage. Continuous variables, including IOP, MAP values over time within the groups were analysed using repeated measures analysis of variance (ANOVA) followed by Bonferroni's post hoc testing. The proportion of patients with Fundus changes, visual loss, retinal nerve layer from preop to postop were reported. P value of 0.05 was considered statistically significant.

Table 1: Demographic data

Demographic parameters	Values
Mean age (years)	37.36±13.89 year
Sex distribution	
Males	25 (56.8%)
Females	19 (43.2%)
Mean weight	60±15 kg
BMI	24.43

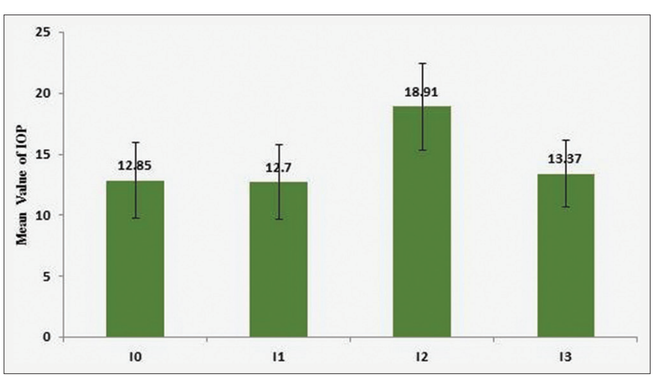

Figure 1: IOP trends in the eye

Discussion

Postoperative visual loss likely to occur after spine surgery, though the incidence is quite, less ranging from 0.019% to 0.2%.[14] Prone operative position, prolonged surgical time, excessive blood loss, and obesity are few predisposing factors. Prolonged prone position result in inadvertent orbital compression, which further increases orbital venous pressure, decreases choroidal blood flow and finally decreased perfusion pressure of optic nerve head.[7]

The current study examined the combined effects of IOP and OPP on the vision of the patients who underwent spine surgery in the prone position. Mean age and weight of the patients were 37.3 ± 13.4 year and 60 ± 15 kg, respectively with male preponderance (25 males vs 19 females) Mean BMI of the patients was 24.43. Demographic data of present study was in accordance to other studies, except few studies reported to have higher mean weight and BMI as compared to our study.[7,15,16]

IOP measurements were done and it was observed that IOP decreased to 12.70 ± 3.06 from baseline (12.85 ± 3.07 mm Hg) following administration of general anaesthesia due to the effect of anaesthetics. Furthermore, this value significantly increased (18.91 ± 3.56

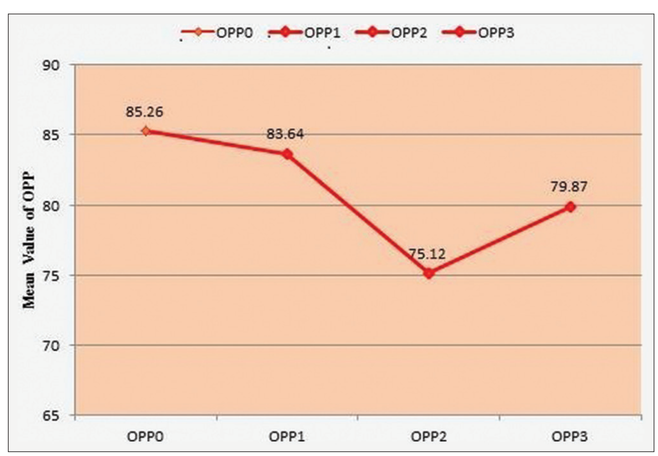

Figure 2: Showing OPP trends

Table 2: IOP, MAP and OPP

	Baseline	After induction	Immediately on turning supine at end of surgery	30 min after extubation	*P*
IOP	12.85±3.07 (I_0)	12.70±3.06 (I_1)	18.91±3.56 (I_2)	13.37±2.74 (I_3)	<0.001*
MAP	97.89±15.78	96.34±17.02	95.64±15.55	93.27±12.30	0.247
OPP	85.26±16.07 (OPP_0)	83.64±17.19 (OPP_1)	75.12±16.45 (OPP_2)	79.87±12.55 (OPP_3)	0.0018*

**Showing significant P (P<0.05)*

Table 3: Duration of surgery and blood loss

Surgical parameters	Values
Mean duration of surgery	122±39.3 min
Average estimated blood loss	300-400 ml
Blood transfusion	Only 2 patients received 350 ml of blood

mm Hg) following the completion of surgery. In 4 patients, this value approached 25 mmHg. Out of these, 3 patients complained of blurring of vision in post operative period, which may suggest that increased IOP can cause discomfort and blurring. The duration of surgery and proper head support is considered to be an important factor in causing IOP changes. Cheng *et al*. reported a significant increase in IOP at the conclusion of the surgery (40 mmHg) when surgery lasted 320 ± 107 min, which was quite high as compared to our study.[15] A significant increase in IOP values at the end of the surgery with median 38 mmHg after 123 min mean duration of surgery, was reported by Hunt *et al*.[16] Increased mean duration of surgery in Cheng's study lead to significantly raised IOP. Hunt *et al*. had nearly the same duration of surgery as present study, despite this mean IOP was higher as compared to the present study. They documented that few patient's head were supported with a pillow and other patient's head were supported in pins. Previous group recorded higher IOP than the later one. In our subjects, we uniformly used a hollow soft sponge to support the head. Significant increase in IOP at the end of the surgery (31.1 mmHg) in prone flat position was reported by Walick *et al*.[17] The use of flat prone position resulted in increased venous pressure which further increased IOP. Emrey *et al*., observed slight drop in IOP in patients with face 10° inclined (22.2 mmHg), as compared to neutral position (23.96 mmHg).[18] They advocated that elevation promotes venous drainage and controls IOP. All the authors had a common agreement that the IOP increase had a direct correlation between the position of the head, pressure on the eyeball and duration of time spent in prone position which can further result in vision problem. The Authors recommend a neutral position with proper positioning to eliminate the extraocular pressure. This prevents twisting of internal jugular vein, which subsequently increases venous pressure and further increases IOP. All possible measures should be adopted to avoid direct eyeball compression and there should be no contact with the headrest and orbit. Many authors advocate the use of silicone headrests to avoid direct eyeball compression.[15-19]

MAP recorded during the perioperative period did not show significant difference in the current study. It changed from baseline value of 97.89 mmHg to 95.64 mmHg on conclusion of surgery. Cheng *et al*. recorded similar observation with a baseline MAP of 98 mmHg which dropped to 91 mmHg at the end of surgery.[15] Similarly, Gencer *et al*. reported an average MAP as 89 mmHg.[20] Maintaining MAP is of prime importance, though it is an indirect but important variable for maintaining optic nerve perfusion pressure. Fall of MAP is considered to be one of the important factor for nerve perfusion.[15,20] as ocular perfusion pressure (OPP) can be calculated by subtracting IOP from mean arterial pressure (OPP = MAP-IOP).[7]

Ocular perfusion pressure in the present study was calculated using above formula. We recorded baseline mean OPP_0 as 85.31 ± 16.05 mmHg, and fall in OPP was noted till 75.13 ± 16.43 mmHg on the completion of surgery. Drop in OPP was significant statistically with $P = 0.001$ but was not up to the extent that it compromises the ocular blood supply. Yang *et al*. found a decrease in OPP in lateral decubitus position to 59.8 ± 13.8 mmHg, where the OPP in supine position was 65.7 ± 12.4 mmHg.[21] Higher IOP values resulted in lower OPP in Yang's study. Gencer *et al*. reported a reduction in OPP in prone position to 64 (46-90) mmHg from baseline, which was 79.5 (53-134) mmHg.[20] This difference in OPP was in contrast to our study despite nearly comparable MAP (89 vs 95.7 mmHg) due to lower IOP measurements of Gencer *et al*.'s subjects. Therefore, it is important to understand that balance between IOP and MAP should be maintained. The authors concluded that IOP elevation in prone position reduces OPP, especially in cases where MAP remains stable and slightly decreased. It can further result in instability in optic nerve circulation, resulting in optic nerve head infarction.[20,21]

Duration of surgery is paramount factor that contributes to significant rise in IOP. The literature states that duration of surgery greater than four hours was a risk factor for perioperative visual loss. Hunt *et al*., Gencer *et al*. and

Table 4: Fundus and visual changes in eye

			Fundus changes in eyes					
***n*=44**	**Normal**	**Tessellated fundus**	**AION**		**PION**		**CRAO**	
			Optic Nerve Head Oedema	**Flame shaped haemorrhage**	**Pupillary light reflex**	**Optic nerve pallor**	**Pale retina**	**Cherry red spot**
Preoperative	43 (97.7%)	1 (2.3%)	-	-	-	-	-	-
Postoperative	43 (97.7%)	1 (2.3%)	-	-	-	-	-	-
P			>0.05					

Visual changes in both the eyes					
Visual changes	**Preoperative**		**Postoperative**		***P***
Normal	44	100.0%	41	93.1%	0.241
Blurring of vision	0	0%	3	6.9%	

Retinal nerve fiber changes in both the eyes					
Retinal nerve fiber layer thickness	**Preoperative**		**Postoperative**		***P***
Normal	44	100.0%	42	95.5%	0.494
Thinning of nerve layer	0	0%	2	4.5%	

Deniz *et al*. recorded nearly the same duration of surgery as ours (122 ± 39.3 minutes).[16,19,20] However, Lee *et al*. (588 min) and Cheng *et al*. (320 ± 107 min) recorded exceptionally higher duration of surgery.[8,15] It was established that more was the duration of surgery greater was the rise in IOP.

Several studies suggested excessive blood loss to be another important factor contributing to visual impairment. Excessive blood loss can indirectly affect perfusion pressure on the optic nerve as it can lead to decreased MAP which in turn further reduces optic nerve perfusion. Present study, Chang *et al*. and Hunt *et al*. reported a blood loss of 300-400 ml, 972 ml and 13.5 L, respectively.[16,22] Hunt *et al*. studied 20 spine surgery patients and did not find any visual loss in any patient, despite excessive blood loss. Rise in IOP was moderate and visual impairment was less in our study, because of less duration of surgery and minimal blood loss as compared to literature. Excessive fluid replacement may effect the IOP measurements, but all the patients in our study received minimal fluid replacement, so possibility of fluid causing IOP change is ruled out.

Fundus was assessed in the postoperative period for optic disc edema, flame shaped haemorrhages suggesting AION, pupillary light reflex and optic nerve pallor suggestive of PION, pale retina and cherry red spot evident of CRAO. No such findings were recorded in the present study. AION is most common in general where, thinning of retinal nerve fibers takes place, because of significant rise in IOP.[9] PION is more common following spine surgery. Postoperative ION is the term used to describe the optic nerve dysfunction that occurs during or in the period just after non-ophthalmic surgeries. PION is associated with large intra-operative blood loss, as well as relative hypotension extended over the duration of the case.[10] Mechanism of CRAO includes thromboembolism or direct compression of the globe, causing increased IOP which in turn decreases perfusion of the retina.[8] In the present study three patients complained of blurring of vision after surgery, on examination, no evidence of any corneal, retinal or optic nerve injury was found. These symptoms recovered completely within 24 hours post-operatively. Blurring of vision could be possibly due to compression of the eyes on the head rest, as these patient's eyes were inadequately padded, which resulted in an increase in IOP . Chang *et al*. in his 20 year retrospective review of 14,102 spine surgeries reported 4 cases of PION. In all the cases, optic disc in the affected eye initially appeared normal, but subsequently became pale.[22] Lee *et al*. analysed 93 spine surgeries retrospectively, 83 patients had ION. Mean anaesthetic duration was 9.8 ± 3.1 hours[22] This incidence was higher in both the studies possibly because of the exceptionally prolonged duration of surgery, increased incidence of hypotension, blood loss anaemia and massive intraoperative blood transfusion and assessment of large number of subjects.[8,22]

Qualitative assessment of retinal nerve fiber layer by ophthalmoscope was done in our patients. We found thinning of the retinal nerve fiber layer in the inferior quadrant in 2 patients when compared to preoperative finding. Gencer *et al*. studied changes in retinal nerve fiber layer thickness in 30 patients. They found significant thinning of inferior and nasal quadrant retinal nerve fibers. However both studies including ours, were not successful in establishing any statistical significant correlation between thinning of retinal nerve fiber layer, duration of surgery, IOP changes and OPP changes.[20] Major drawback of the present study was our inability to use ophthalmic computed tomography (OCT) to assess retinal nerve fiber layer because majority of the patients enrolled in the study were of fracture spine and they were not allowed the sitting posture to avoid risk of neurological deficit.

Conclusion

The present study support the concept that posture has a gross effect on IOP and OPP. Besides increase in IOP and decrease in OPP, factors like surgical time, intraoperative hypotension and blood loss plays a significant role causing ophthalmic complications. But in the current study, we did not observe any major ophthalmic complications despite a significant increase in IOP and a significant decrease in OPP because of optimal surgical time and minimal blood loss. Hence careful positioning, with no extrinsic pressure on the eyes, prevention of intraoperative hypotension, minimal surgical time and minimal blood loss during the surgery are of utmost importance from the anaesthesia point of view to avoid ophthalmic complications.

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Conflicts of interest
There are no conflicts of interest.

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