Prone Position in Percutaneous Nephrolithotomy and Postoperative Visual Loss

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Purpose: To study the simultaneous effects of prone position and anesthesia on intraocular pressure (IOP) and the time impact on post anesthesia visual loss development in percutaneous nephrolithotomy (PCNL).

Materials and Methods: Twenty patients who were candidates for PCNL were recruited in this study. Intraocular pressure was measured in five occasions:

1. Base line; 2. Ten minutes after anesthesia (Supine-I); 3. Ten minutes after position change to prone (Prone-I); 4. At the end of the operation (Prone-II); and 5. Ten minutes after position change to supine (Supine-II).

The data were analyzed by SPSS software using repeated measures ANOVA and paired *t* test.

Results: The participants consisted of 17 (85%) men and 3 (15%) women, with the mean age of 44 years. The duration of the prone position was 79.75 ± 22.73 minutes. Intraocular pressure changed significantly in five positions ($P = .000$). It was lower in supine-I than baseline, higher in prone-I than base line and supine-I, lower in supine-II than prone-II, and highest in prone-II ($P = .000$). There was a linear relationship between IOP and prone position duration ($r = 0.67$; $P = .001$).

Conclusion: Intraocular pressure dropped significantly after anesthesia and increased in prone position. There was a linear relationship between IOP rise and the prone position duration, doubled within two hours. Therefore, in PCNL carried out in prone position, it is recommended to observe safety measures and necessary precautions for IOP rise and possible post anesthesia visual loss, particularly in glaucoma.

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INTRODUCTION

Of peri-operative complications, post anesthesia visual loss (PVL) is one of the most important ones reported in numerous articles.(1-6) Post anesthesia visual loss is an unfortunate, horrifying, and rare complication that is among the legal complaints.(7) It has been mostly reported in spinal surgeries and the prone position.(3) Several factors, including hypotension, anemia, and the pressure on the eyes may lead to PVL.(2) However, some researchers have suggested that hemorrhage, changes in blood pressure, hematocrit level alterations, and the volume of fluid replacement during the operation might not be contributory factors in development of PVL.(7) Reduction in eye's perfusion, the volume of blood loss, and the replacement fluids have been mentioned as the most common factors that lead to PVL.

Ischemic optic neuropathy (ION), in which either the anterior (AION) or the posterior (PION) section of the nerve is involved, is the most common cause of PVL.[6] Ho and colleagues studied the ION after the spinal cord surgeries in prone position and reported that mostly the external part of the nerve was affected by ischemia and was frequently bilateral (40% for AION and 47% for PION).[8]

Unfortunately, nowadays, the routine check of the optic nerve blood flow is not carried out.[7] The anterior and posterior sections of the nerve are supplied separately by the posterior branches of the ciliary artery and perforating arteries, respectively. Over 20% of normal populations have abnormal autoregulation that is undetectable clinically.[9] Blood vessels are compressible easily at the posterior section of the optic nerve and with the alteration in the eye perfusion pressure, some patients become susceptible to ION,[10,11] and atherosclerosis worsens the situation.[11] In normal patients, reduction in the eye perfusion in the range of autoregulation is tolerable, but in the existence of atherosclerosis, there is a possibility of blood flow reduction in the nerve,[12] and patients with vascular impairment are at higher risk of developing ION.[10,11] Optic nerve is sensitive to acute bleeding; nonetheless, acute hemodilution is not precarious and therefore there is no need to extra blood.[6,7] Hemodilution and hypotension are routine in open heart surgery, but PVL is rare.[7]

Generally, PVL is not caused by direct pressure on the eye globe, but the main factor is the effect of hemodynamic alterations on ocular perfusion pressure (OPP) that is the result of subtracting the intraocular pressure (IOP) from mean arterial pressure (MAP); OPP = MAP – IOP.[13] Yet in ocular perfusion, the attention has been focused more on holding MAP normal or high, and IOP has been left relatively unnoticed, since even if MAP is steady, a high IOP prevents a proper OPP. Hypotension also decreases IOP, which in turn reduces OPP.[14]

In a study on the effect of position on IOP in awake patients, the pressure raised from 13.5 mmHg in supine position to 20 mmHg in the prone position.[15] Prone position causes an increase in the peritoneal pressure with subsequent increase in IOP, peak inspiratory pressure (PIP), and central vein pressure. In the patients not suffering from glaucoma, the peritoneal pressure during the laparoscopic surgery did not yield increased IOP in the lithotomy position,[16] but IOP increased in glaucomatous rabbits.[17] Intraocular pressure showed an increase in the anesthetized patients and the awake volunteers in the supine position with low head placement (Trendelenburg). The mechanism is the rise in the episcleral venous pressure.[9] Furthermore, general anesthesia reduces IOP.[18] The rise in $PaCO_2$ could increase IOP during the general anesthesia in the supine position,[19] but $PaCO_2$ does not change substantially during general anesthesia.[20] In a study, the rises of $PaCO_2$ and end-tidal carbon dioxide concentration (ETCO2) in the prone position were reported.[21] The balance between the prone position and general anesthesia plays an important role in OPP.

Percutaneous nephrolithotomy (PCNL) is relatively a new technique and the treatment of choice for removing stones in the kidney, proximal ureter, inferior pole of the kidney, or infundibulopelvic and the stones accompanied by the evidence of obstruction. This operation usually results in low blood loss and the overall need for blood transfusion is less than 10%.[22] To carry out this operation, there is mostly a need to general anesthesia. Although PCNL is usually completed in prone position, performing it in the supine and flank positions is still under debate.[23-26]

The aim of this study was to investigate the simultaneous effects of anesthesia and prone position on IOP during PCNL and the risk of developing PVL.

MATERIALS AND METHODS

This study was a non-controlled, non-randomized, and non-blinded (pre post quasi-experimental design) clinical trial that was carried out on 20 patients candidate for PCNL. All of them were in American Society of Anesthesiologists (ASA) class I to III. The written informed consents were obtained from each participant.

Patients with a history of either eye disease or eye surgery were excluded from the study. The demographic and clinical data were collected using a questionnaire.

All the patients had hematocrits above 30% and the duration of patients' fasting was 8 hours. First, electrocariography monitors, non-invasive sphygmomanometer, pulse oximetry, and nerve stimulator were connected to the patient. Both eyes were anesthetized by 0.5% tetracaine. Before prescription of any premedication, the pressures of both eyes were measured in supine position by Tono-Pen XL hand-held applanation tonometer (Baseline). The mean of 4 measurements with the right standard deviation of less than 5% was acceptable that otherwise the measurement was repeated.

Anesthesia protocol was the same for all the patients and achieved as follows: Premedication with xylocaine 1.5 mg/kg and fentanyl 1 to 2 μg/kg. Induction with nesdonal 3 to 5 mg/kg and atracurium 0.5 mg/kg and the continuation of the anesthesia by fentanyl 1 to 2 μg/kg/h infusion, halothane 0.5% to 0.6%, and N_2O 50%.

Mean arterial pressure was regulated at the range of 20% of wakefulness and ventilation on the basis of $ETCO_2$ 30 to 35 mmHg. In order to maintain the intravascular volume during the operation, in addition to the precise compensation of the hemorrhage, 5 mL/kg normal saline was prescribed for each patient. Any subject with the hemorrhage of greater than 1000 cc was excluded from the study. By controlling train of four, the timing for intubation and the re-prescription of the muscle relaxants were determined that in the case of the existence of more than one twitch, muscle relaxant (0.1 mg/kg) was repeated. Particularly, at the time of the position change, patient was sustained flaccid and in deep anesthesia.

The IOP was measured in the following stages:

1. Awakeness and in supine position (Baseline)
2. Ten minutes after induction and in supine position (Supine-I)
3. Ten minutes into acquiring prone position (Prone-I)
4. At the end of the operation in prone position (Prone-II)
5. Ten minutes into acquiring supine position (Supine-II) before the reverse injection and the change in depth of anesthesia

Simultaneously, in the above-mentioned stages, PIP, end-tidal halothane (ET Hal), $ETCO_2$, pulse rate, saturation of peripheral oxygen (SPO_2), and MAP were measured as well.

The XL hand-held tonometer was calibrated after each use. The change of position was carried out by the same team, considering all necessary precautions gently for all the patients. Applying pressure on the eyes was avoided during the prone position and a gelatinous head ring was placed under the patient's head without any contact with the eyes. The method of operation was unchanged. The surgeon, surgical equipment, the evaluators, and persons who collected the data were the same for all the patients.

The patients were questioned concerning the visual acuity or any other visual disturbances in both eyes in the recovery room. Pre and postoperative hematocrit level as well as urine output and blood loss were measured.

The data were analyzed by SPSS software (the Statistical Package for the Social Sciences, version 11.0, SPSS Inc., Chicago, Illinois, USA) using repeated measures ANOVA and paired *t* test. *P* values less than .05 were considered significant.

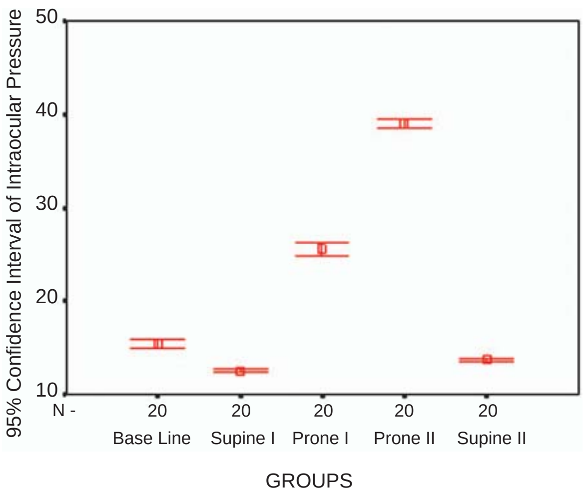
RESULTS

The participants consisted of 17 (85%) men and 3 (15%) women, with the mean age of 44 years. The duration of the prone position was 79.75 ± 22.73 minutes. No significant differences were observed regarding PIP, $ETCO_2$, MAP, SPO_2, and ET Hal in the five stages.

Since the statistical differences were unavailable between the right-eye and the left-eye IOPs, we considered the left-eye IOP in our calculations. The measured IOP ranged between 12 and 40 mmHg and it was observed that IOP changed

Patients' mean intraocular pressures in five occasions

	N	Mean (Range), mm/Hg	Std. Deviation	Std. Error	95% Confidence Interval for Mean
Base line	20	15.42 (14.00 to 17.00)	.8777	.1963	15.01 to 15.83
Supine I	20	12.55 (12.00 to 13.00)	.5104	.1141	12.31 to 12.78
Prone I	20	25.55 (20.00 to 28.00)	1.5381	.3439	24.83 to 26.26
Prone II	20	38.95 (37.00 to 40.00)	.9445	.2112	38.50 to 39.39
Supine II	20	13.75 (13.00 to 14.00)	.4443	9.934E-02	13.54 to 13.95
Total	100	21.24 (12.00 to 40.00)	10.0696	1.0070	19.20 to 23.20



Patients' mean intraocular pressures in five positions in percutaneous nephrolithotomy

significantly in the five positions (*P* = .000). The IOP in supine I (12.5 ± 0.5 mmHg) was lower than the baseline (15.42 ± 0.9 mmHg) (*P* = .000). The intraocular pressure in prone I (25.5 ± 1.5 mmHg) was higher than supine I and the baseline (*P* = .000). The IOP in prone II (38.9 ± 0.9 mmHg) was higher than all previous measurements (*P* = .000). The IOP in supine II (13.7 ± 0.4 mmHg) was lower than prone II (P = 0.000) (Table and Figure). There was a linear relationship between the IOP and duration of the prone position (r = 0.67; *P* = 0.001) that the IOP rose as the time elapsed.

DISCUSSION

To the best of our knowledge, this study is the first one on the IOP in PCNL and the effect of the duration of the prone position on the anesthetized patients. In this study, anesthesia reduced the IOP, which is in line with other studies showing that administration of anesthetic drugs, such as nesdonal and atracurium, resulted in reduction of the IOP.[27] The other finding is that the position change to prone leads to alteration of the IOP in a way that not only it compensates the reducing effects of the anesthetic drugs in 10 minutes, but also exceeds the baseline. The effects of the prone position have also been demonstrated in a study by Lam and Douthwaite, in which the IOP raised within 8 minutes after the change of position to prone.[15] They carried out the trial on awake volunteers. Our study showed that the increasing effect of the prone position on IOP is stronger than the reducing effects of general anesthesia on IOP.

The most accurate method of measuring IOP over the time is its continuous and invasive measurement. This type of recording IOP has been reported in two groups of patients by implanting a probe into the anterior chamber of the eye for 96 hours.[28] However, we utilized Tono-Pen XL similar to the study by Lam and Douthwaite.[15] The accuracy of this device in comparison with the invasive method of probe implantation has been demonstrated by Setogawa and Kawai.[29] Rises in $PaCO_2$ and $EtCO_2$ have been reported in the prone position.[21] Since the rise of the $PaCO_2$ could increase the IOP,[21] we kept $PaCO_2$ unchanged from the beginning to the end of the anesthesia in order to abolish its interfering effects.

A number of researchers induced a rise in the IOP by increasing the acute fluid administration.[25] In our study, we compensated not only the fluid loss, but also the patients received 5cc/kg/h of fluid. The point that the intravascular volume change is capable of changing the IOP requires prospective studies.[27] Nonetheless, we maintained the fluid balance and the intravascular volume in a steady state in order to prevent the possible effects of the intravascular volume.

Unlike the study by Pillunat and colleagues, our patients were in a position completely in parallel to the horizontal surface, and therefore, the effects of increase or decrease in episcleral intravenous pressure due to the Trendelenburg position could not be measured in our study.[9]

Fortunately, we did not observe any visual loss after anesthesia, but the first reported case of PVL after PCNL in the Labbafinejad Medical Center was a 75-year-old man with the history of diabetes mellitus, hyperlipidemia, and mild anemia. The patient had painless PVL in both eyes limited to light perception immediately after the operation. In ophthalmologic examination, the optic disc was pink without swelling and visual fields were severely affected; however, neuroimaging was normal. The visual fields and acuity improved dramatically in a matter of three months, but optic disc turned slightly pale and this was the first report of PION after PCNL.[30]

According to the report by Roth and Barach, there is a possibility of PVL in the prone position, with hypotension, anemia, and direct pressure to the eyeball as risk factors.[7] In our study, we have avoided all the three mentioned factors and the fact that whether or not it is the reason for no visual loss after anesthesia is not assessable with this number of patients and it requires further studies.

On the other hand, it does not seem that acute hemodilution is precarious. Since hemodilution occurs frequently in open heart surgery, but visual loss usually occurs after the spinal surgeries in prone position.[22] In a study on 20 anesthetized patients in spinal surgery in prone position, Hunt and coworkers reported the rise in the IOP. Nevertheless, the duration of the operation, age, and body mass index have been mentioned as non-contributory factors.[31] According to the report of Ho and colleagues in assessing the reasons for ION duration, the prone position has been lengthy in all the subjects with the average of 450 minutes, which points to the time factor in the development of ION in prone position.[8] Also the reduction of OPP, intra-operative bleeding, anemia or hemodilution, and the infusion of large amounts of intravascular fluids are among the aggravating factors in ION.[8]

In healthy volunteers, IOP increases with the acute rise in the fluid load,[25] and dehydration due to physical exercise reduces IOP.[32] The reduction in osmolarity during dialysis also increases IOP.[33] Prospective studies are required in order to demonstrate the relationship between the fluid balance and IOP in prone position.[27]

In a comprehensive literature review on visual loss after non-ocular surgeries, it has been reported that risk of decrease in visual acuity and visual ability rises in case of preexisting diseases, such as hypertension, diabetes mellitus, sickle cell anemia, renal failure, gastrointestinal ulcer, narrow-angle glaucoma, vascular occlusive disease, cardiac disease, arteriosclerosis, polycythemia vera, and collagen vascular disorders. Furthermore, the precipitating factors for ION include prolonged hypotension, anemia, surgery, trauma, gastrointestinal bleeding, hemorrhage, shock, prone position, direct pressure on the globe, and long operation time.[34]

In our study, the effect of the duration of the prone position on the rise of IOP was significant and other factors were ruled out. All the patients had the blood pressures of above 120 mmHg during the operation. By maintaining other conditions unchanged, it was tried to study the effect of the duration of the prone position on IOP in PCNL. After doubling the IOP from the normal level,[35] the risk of damage to the optic nerve starts, and according to our study the IOP was doubled and reached up to 40 mmHg after two hours.

CONCLUSION

Since in PCNL the rise of IOP in the prone position has a linear relationship with time and doubles within two hours, it is recommended that in the prone position surgeries, special attention has to be focused on the IOP. Prospective larger studies on the IOP with different setting are needed to confirm our results.

CONFLICT OF INTEREST

None declared.

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