Effectiveness of reverse Trendelenburg in alleviating intraocular pressure in patients undergoing surgery in the prone position: a systematic review protocol

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Review question/objective: The objective of this review is to identify the effectiveness of reverse Trendelenburg in alleviating intraocular pressure in patients undergoing surgery.

Keywords Intraocular pressure; prone position; surgery; Trendelenburg

Background

Postoperative vision loss (POVL) is a catastrophic complication that affects one in 61,000 patients undergoing general anesthesia. This rare debilitating condition remains at the forefront of patient safety concerns, ranking 11th in the 53 facets of importance cited by anesthesiologists. Ocular complications comprise 3% of all of the American Society of Anesthesiologist closed claims and are allied with greater financial settlements than non-ocular grievances. A multifaceted etiologic basis has emerged postulating variables that impede ocular perfusion pressure (OPP) as culprits to this phenomena. Cited perioperative risk factors contributing to the development of POVL include surgical duration, hypotension, prone positioning, large blood loss, increased intraocular or venous pressure, comorbid conditions leading to alterations in the microvasculature and hemodilution secondary to volume replacement.

The optic nerve comprises the optic disc and a fraction of the nerve that resides within the scleral canal. The scleral canal is a circular chamber that collects aqueous humor from the anterior chamber and returns it into the systemic circulation by way of the anterior ciliary veins. The preponderance of the blood supply is from a branch of the ophthalmic artery, the posterior ciliary artery, with only a fraction of the perfusion being supplied by the retinal arterioles to the superficial disc. Compromised blood supply from one of these respective sources leads to regional damage of the optic nerve yielding one of two designations: anterior ischemic optic neuropathy or posterior ischemic optic neuropathy (PION).

Ischemic optic neuropathy (ION) is the most prevalent cause of POVL. The anterior optic nerve circulation may be preserved by autoregulatory mechanisms synonymous to cerebral circulation. This compensatory mechanism serves to protect the anterior aspect of the optic nerve from ischemia when hemodynamic aberrations occur during surgery. This protective mechanism may be void in disease states that affect the circulatory system leading to the uncertainty of its significance as a protective mechanism against ION in comorbid subjects.

Posterior ischemic optic neuropathy is the predominant classification of ION that matures into a permanent visual deficit. Permanent visual deficits are estimated in one of 1100 patients placed in the supine position and are a consequence of intraorbital optic nerve infarctions. The branches of the posterior ciliary artery that supply the lateral aspect of the optic nerve are known as the watershed zone. The lack of compensatory blood redistribution leaves the watershed zone vulnerable to oxygen debt. The increase in intraocular pressure (IOP) that accompanies prone positioning compromises ocular perfusion resulting in oxygen deprivation and may contribute to the 0.01–1% incidence of
Debilitating postoperative vision loss.\textsuperscript{3,5,6} Doppler imaging illustrates a relationship between rises in IOP and a subsequent decrement in flow velocity through the posterior ciliary arteries, thus leading to a diminution in oxygen in the watershed zone.\textsuperscript{7}

Posterior ischemic optic neuropathy and anterior ischemic optic neuropathy have a similar clinical presentation and characteristically manifest as reports of painless visual loss, non-reactive pupils, absence of light perception and visual field deficits.\textsuperscript{1} A distinguishing attribute of PION is the involvement of bilateral eyes. Visual loss ensues most characteristically in the first 24–48 hours; however, notable deficits have been documented upon awakening from anesthesia. Progressive optic atrophy continues over subsequent weeks to months, resulting in devastating, permanent vision loss. The predominance of POVL claims is in patients placed in the prone position for spine surgeries leading to positioning being a prevailing facet of significance in the study of IOP.\textsuperscript{5,7}

The prevalence of ophthalmic injury is 10-fold in patients placed in the prone position.\textsuperscript{4,5} General anesthesia results in a reduction in IOP; however, research has shown that this decrease is attenuated when patients are placed in the prone position for spinal surgery.\textsuperscript{2,3} Similar increases in IOP are seen in awake participants when placed in the prone position.\textsuperscript{2} The exact reason why PION occurs during prone position surgeries is not well understood, but previous studies hypothesize decreased OPP. Ocular perfusion pressure is delineated as the difference between mean arterial pressure (MAP) and the IOP.\textsuperscript{2,4} The increase in IOP that accompanies prone positioning therefore necessitates a higher MAP to preserve the delivery of oxygen and nutrients to the optic nerve. Additionally, compression of large veins in the abdomen leads to an increase in central venous pressure. An elevation in central venous pressure impinges upon venous drainage leading to vascular congestion. Decreased venous drainage, or outflow of aqueous humor, translates into an increased IOP. This opposes blood flow through the posterior ciliary arteries resulting in an ischemic insult to the watershed zone of the optic nerve.

Research has historically suggested that not only does decreased venous drainage contribute to increased IOP while in the prone position but also extraocular pressure and time spent in the prone position can result in an increased IOP. A specific source of extraocular pressure investigated by Bekar \textit{et al.}\textsuperscript{7} was the usage of a horseshoe-shaped headrest.\textsuperscript{2,7} Research by Cheng \textit{et al.} instituted measures to eliminate extraocular pressure as a confounding variable, yet research subjects continued to exhibit an increase in IOP when placed in the prone position suggesting a multifarious dilemma. A systematic review conducted by Torossian \textit{et al.}\textsuperscript{8} aimed to isolate an etiologic basis of POVL.\textsuperscript{5} Data extracted supported the notion that prone position is a precipitating factor, with spinal surgery having a 0.08% incidence of POVL. Further investigation on modifiable risk factors, such as alterations in patient positioning, may help to alleviate untoward increases in IOP, thus preserving sufficient blood supply to the optic nerve. Research suggests that reverse Trendelenburg, inclination of a prone patient with the head raised above the feet, may help to increase venous drainage blunting rises in IOP and serves as a protective modality to modify a patient’s risk for POVL.\textsuperscript{2–5}

The notion that body positioning influences IOP has reinforced the merit of investigating table inclination as a protective strategy to optimize OPP.\textsuperscript{2–6,9,10} In a study of inverted humans, Friberg \textit{et al.} found a 1-mmHg increase in IOP for every 0.83 mmHg increase in episcleral venous pressure.\textsuperscript{2–6,9} Episcleral venous pressure is continuous with the central circulation through a system of valve-less veins, thereby translating pressure changes brought forth by anatomical positioning to the eye. An anesthetist should be cognizant of the significance of prone positioning on bilateral IOP in the absence of extraocular forces.\textsuperscript{2} A noteworthy rise in IOP is discernible within minutes of prone positioning.\textsuperscript{3} This reinforces the principle that increases in central venous pressure in the prone position translates into rises in IOP. Reverse Trendelenburg, head-up position, may be an amicable solution to ameliorate increases in IOP.\textsuperscript{2–5}

Preoperative ocular disease may be associated with underlying variations in ocular anatomy, blood supply and ocular pressures. Subjects with a positive ocular disease history must be eradicated from this literature review to negate bias in the research findings in acquisition of the true merit of protective positioning modifications.

The incidence of permanent ophthalmic disturbances in prone patients urges one to appraise solutions to remedy this devastating perioperative
complication. Prone positioning has emerged as a foremost culprit of perioperative visual disturbances. Modifications in the prone position may be a reasonable, cost effective and implementable solution to reduce one’s risk of ION. A preliminary search of databases, including EMBASE, Clinical Key, Web of Science, PubMed, Cochrane Central Register of Controlled Trials and CINAHL yielded no findings of prior systematic reviews evaluating positioning modifications as a protective strategy for POVL. Therefore, this systematic review will consider the effects of reverse Trendelenburg as a protective positioning modification during surgeries in the prone position to circumvent increases in IOP. Appraisal of the impact of MAP on ocular perfusion and visual acuity will be undertaken as secondary outcomes of interest.

Inclusion criteria
Types of participants
Participants should have no past medical history of ocular disease or ocular surgery. Two groups will be included: anesthetized patients undergoing any surgery except for ocular surgery and awake participants. Both groups will be considered because similar changes in IOP have been observed while in the prone position. Participants with diseases affecting the microvasculature will be included in the absence of previously documented ocular pathology.

Types of intervention(s)/phenomena of interest
This review will consider studies that evaluate the use of reverse Trendelenburg at a minimum of 5 degrees in combination with the prone position compared to the prone position with no table inclination.

Outcomes
This review will consider studies that include the following primary outcome measure: IOP as measured by an ocular tonometer measured in millimeters of mercury (mmHg). Secondary outcomes will include MAP on ocular perfusion measured in mmHg and visual acuity. Visual acuity will be reported as the presence or absence of a deviation from the participant’s baseline.

Types of studies
This review will consider any experimental study design, including randomized controlled trials, non-randomized controlled trials, quasi-experimental, before and after studies for inclusion.

Search strategy
The search strategy aims to find both published and unpublished studies. A three-step search strategy will be utilized in this review. An initial limited search of MEDLINE (PubMed) and CINAHL will be undertaken followed by analysis of the text words contained in the title and abstract and of the index terms used to describe the article. A second search using all identified keywords and index terms will then be undertaken across all included databases. Third, the reference list of all identified reports and articles will be searched for additional studies. Studies published in English will be considered for inclusion in this review. Studies published at any time will be considered for inclusion in this review.

The databases to be searched include:
- EMBASE
- Clinical Key
- Cochrane Central Register of Controlled Trials
- Web of Science
- MEDLINE (PubMed)
- CINAHL

The search for unpublished studies will include:
- Google Scholar
- World Health Organization’s International Clinical Trials Registry Platform Search Portal
- Clinical Trial Information
- New York Academy of Medicine Gray Literature

Initial keywords to be used will be: intraocular pressure or IOP, postoperative vision loss or POVL, prone

Assessment of methodological quality
Articles selected for retrieval will be assessed by two independent reviewers for methodological validity prior to inclusion in the review using standardized critical appraisal instruments from the Joanna Briggs Institute Meta-Analysis of Statistics Assessment and Review Instrument (JBI-MAStARI, Appendix I). Any disagreements that arise between the reviewers will be resolved through discussion or with a third reviewer.

Data extraction
Data will be extracted from articles included in the review using the standardized data extraction tool
from JBI-MAStARI (Appendix II). The data extracted will include specific details about the interventions, populations, study methods and outcomes of significance to the review question and specific objectives.

Data synthesis

Quantitative data will, wherever possible, be pooled in statistical meta-analysis using JBI-MAStARI. All results will be subject to double data entry. Effect sizes expressed as odds ratio (for categorical data) and weighted mean differences (for continuous data) and their 95% confidence intervals will be calculated for analysis. Heterogeneity will be assessed statistically using the standard $\chi^2$. Where statistical pooling is not possible, the findings will be presented in narrative form, including tables and figures to aid in data presentation, wherever appropriate.

References

Appendix I: Appraisal instruments

**MAStARI appraisal instrument**

**JBI Critical Appraisal Checklist for Randomised Control / Pseudo-randomised Trial**

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Overall appraisal: [Include] [Exclude] [Seek further info]

Comments (Including reason for exclusion)

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Appendix II: Data extraction instruments

**MAStARI data extraction instrument**

**JBI Data Extraction Form for Experimental / Observational Studies**

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**Study Method**

- [ ] RCT
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- [ ] Retrospective
- [ ] Observational
- [ ] Other

**Participants**

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**Interventions**

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**Authors Conclusions:**

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**Reviewers Conclusions:**

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