Current intraoperative devices to reduce visual loss after spine surgery

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Postoperative visual loss (POVL) after spine surgery performed with the patient prone is a rare but devastating postoperative complication. The incidence and the mechanisms of visual loss after surgery are difficult to determine. The 4 recognized causes of POVL are ischemic optic neuropathy (approximately 89%), central retinal artery occlusion (approximately 11%), cortical infarction, and external ocular injury. There are very limited guidelines or protocols on the perioperative practice for “prone-position” surgeries. However, new devices have been designed to prevent mechanical ocular compression during prone-position spine surgeries. The authors used PubMed to perform a literature search for devices used in prone-position spine surgeries. A total of 7 devices was found; the authors explored these devices' features, advantages, and disadvantages. The cause of POVL seems to be a multifactorial problem with unclear pathophysiological mechanisms. Therefore, ocular compression is a critical factor, and eliminating any obvious compression to the eye with these devices could possibly prevent this devastating perioperative complication.

(http://thejns.org/doi/abs/10.3171/2009.8.FOCUS09151)

KEY WORDS • postoperative visual loss • central retinal artery occlusion • cortical infarction • ischemic optic neuropathy

Postoperative visual loss after “prone-position” spine surgery is a rare but devastating postoperative complication in patients who undergo prone-position procedures. The incidence and the mechanisms of visual loss after surgery are difficult to determine. The American Society of Anesthesiologists Postoperative Visual Loss Registry arose in 2006. The incidence reported in the literature varies between 0.028% and 1.3%. However, several case series and studies have been published recently, increasing the awareness of POVL among anesthesiologists, spine surgeons, and ophthalmologists over the past 5–10 years. The procedures most commonly associated with perioperative ION are coronary artery bypass grafting and back or spine surgery.

The 4 recognized causes of POVL are ION, CRAO, cortical infarction, and external ocular injury. The 2 different forms of ION, anterior and posterior, are the most common (approximately 89%). The cause of the ischemic damage to the optic nerve is still not completely understood, but perioperative anemia, perioperative hypotension, increased venous pressure, head-down operative position, increased CSF pressure, embolism, facial or orbital edema, and direct ocular pressure are reported as the most common etiological factors. However, during the perioperative period, more than one hemodynamic parameter is altered, suggesting that the cause of ION may entail a combination of factors. In addition, preexisting comorbidities, such as systemic hypertension, hypercholesterolemia, diabetes mellitus, arteriosclerosis, heart disease, and smoking have been identified as additional risk factors. Our conclusion is that ION appears to be caused by hemodynamic derangements in conjunction with a patient-specific susceptibility. Complete recovery of vision is seldom reported, and the prognosis for total visual recovery is low. The second most frequent cause of POVL identified in the literature (approximately 11%) is CRAO. It is usually caused by intraoperative compression of the eye by the horseshoe headrest. External compression of the eye could increase intraocular pressure, decreasing perfusion pressure and causing CRAO.

Relevant data reported that the anesthesiologist examined the patient’s eyes in only 51% of the patients in whom ION was diagnosed after prone-position surgery. Most of the authors suggest particularly vigilant assessment of the eyes at the time of positioning and regularly during the procedure. Special emphasis should be given to protecting the eye against pressure during spine surger-
ies, avoiding hypotension and hypovolemia, especially in patients with predisposing factors.

There are many significant factors in POVL, and the pathophysiological mechanism of this syndrome is still unclear and probably multifactorial. However, several reports suggest that the most important factors related to POVL are adequate patient positioning and monitoring during prone-position surgeries. Experts agree that the patient’s head position should be placed at the level of or higher than the heart when possible. Even though POVL seems to be a multifactorial problem with unclear pathophysiological mechanisms, ocular compression is a critical factor, and eliminating any obvious compression on the eye will prevent this devastating perioperative complication.

Ocular compression is mostly attributable to the difficulty of positioning, monitoring, and accessing the patient’s head before and during surgical procedures. To address these challenging factors and allow OR personnel to have complete control over head position and monitoring, classic devices have been modified and designed to prevent mechanical ocular compression during surgical procedures in which the patient is placed prone. Table 1 lists the advantages and disadvantages of each of the devices discussed below.

**Classic Horseshoe-Shaped Headrest**

The patient’s head is held by this device and precariously maintained by bandages. This device (Fig. 1) provides inadequate stabilization of the head, allowing for anteroposterior and lateral or rotatory movements. Also the headrest has contact with one of the eyes, even if these have been well protected from the beginning of the surgery.

**TABLE 1: Devices used for surgery performed in patients in the prone position**

<table>
<thead>
<tr>
<th>Device</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>classic horseshoe-shaped headrest</td>
<td>provides support of pt’s head</td>
<td>provides inadequate stabilization of the head</td>
</tr>
<tr>
<td>foam-cushion face mask &amp; see-through operating table</td>
<td>maintains neck in a straight-line position</td>
<td>allows AP &amp; lateral head movements</td>
</tr>
<tr>
<td>OPTI-GARD eye protector</td>
<td>mirror mounted underneath, allows real-time monitoring of pt’s face position &amp; tubing</td>
<td>not available on the market</td>
</tr>
<tr>
<td>prone positioner (VOSS Medical Products)</td>
<td>protective mask for trauma or unintentional contact to the eyes</td>
<td>does not allow adequate pt monitoring when sterile drapes are placed on top</td>
</tr>
<tr>
<td>ROHO neoprene pillow</td>
<td>minimizes pressure in the face &amp; eyes</td>
<td>compressive injuries have been reported when this device is used in conjunction w/ foam headrests</td>
</tr>
<tr>
<td>ProneView Protective Helmet System</td>
<td>offers lower face-to-pillow interface pressures, providing a larger contact on the surface area of the chin skin</td>
<td>highest surface pressures compared w/ other devices</td>
</tr>
<tr>
<td>ProneView Video Camera Monitoring System</td>
<td>allows an easy examination &amp; monitoring of facial structures</td>
<td>not disposable</td>
</tr>
<tr>
<td></td>
<td>allows monitoring of pt’s eyes &amp; pressure-sensitive structures monitoring is direct &amp; takes place in real time by looking at the image on the LCD monitor, even under the drapes device projects a clear image even when OR lights are off</td>
<td>does not provide overall low face-to-pillow interface pressures; demonstrated to generate a higher interface pressure on the forehead</td>
</tr>
</tbody>
</table>

* AP = anteroposterior; pt = patient.
supervise airway devices. A mirror mounted underneath allows for real-time monitoring of the patient’s face position and tubing for the duration of the surgery.11

**OPTI-GARD Eye Protector**

This is a noncompressible eye protection mask used to prevent trauma or any unintentional contact (Fig. 2). The OPTI-GARD is a latex-free, self-adhering lens produced by Dupaco, Inc., that is marketed as a Class I FDA device and is categorized as an “ophthalmic shield.” This device is used in some institutions in addition to the headrest. The eye protector is placed while the patient is still in the supine position. After the patient has been rolled over into the prone position, the anesthesiologist ensures the correct position of the device headrest.5 Although this device has been created to protect the patient’s eyes against any unintentional contact, compressive injuries have been reported when it is used in conjunction with foam headrests. The injuries can occur when the OPTI-GARD plastic lens is loosened and/or compressed, resulting in a higher probability of inadvertent eye compression.13

**VOSS Prone Positioner**

This is a disposable polyurethane foam prone head positioner that is not contoured to the face, with a T-shaped hole for the eyes and nose (VOSS Medical Products) (Fig. 3). It has the highest surface pressures compared with the other devices. The patient’s face is directly rested on the square-shaped foam, minimizing pressure on the face and eyes during prone-position procedures, thus preventing skin damage and ocular compression.2

**ROHO Neoprene Pillow, “Dry Flotation” Device**

This device, made by The ROHO Group, is a washable prone face positioner made of multiple adjustable neoprene air bladders that imitate cushions, which are used to prevent pressure ulcers in patients who need to be immobilized for long periods.10 According to a pressure surface study, this device offers lower face-to-pillow interface pressures due to a larger surface area in contact with the chin skin. An advantage of this device is that it protects most facial structures from compression.

**ProneView Protective Helmet System**

This system made by Dupaco, Inc. (Fig. 4) consists of a rigid helmet, disposable soft-foam prone head positioner insert, and a standard or an adjustable mirror. The foam is contoured to fit comfortably over the face and prevent contact with the eyes, nose, and mouth. It widely distributes the pressures among the head’s bony structures to reduce surface pressure on the face. This system is applied after induction of anesthesia and intubation. The endotracheal tube needs to be disconnected to set up the device and place the patient prone. The helmet can be held using anterior pressure with one hand while the other hand provides support in the opposite direction around the patient’s occipital region. The patient can then be rolled on top of the OR table, and finally the legs of the helmet can be placed on top of the mirror. After reconnecting the endotracheal tube and confirming adequate ventilation, the facial structures can be examined by direct vision through the mirror to verify any changes in the position of the face during rollover.9 This device allows easy examination and monitoring of facial structures during prone-position procedures. According to a facial and periorbital pressure point study, this device offers less surface pressure than a regular prone-positioner foam support.2

**ProneView Video Camera Monitoring System**

The ProneView Video Camera Monitoring System, made by Dupaco, Inc. (Fig. 5) is a new intraoperative device system that consists of the ProneView Protective Helmet System, an LCD monitor, and a camera cartridge. The correct setup of this device is similar to that for the
ProneView Protective Helmet System: the cushion is fitted inside the ProneView helmet and placed on the patient’s face, making sure the eyebrows are visible, while the patient is supine. The ProneView helmet is held securely on the face during the turn into the prone position. After turning the patient prone onto the mirror camera platform, the face and cushion are rechecked for fit, and adequate position of the face and endotracheal tube is ensured. The LCD monitor, placed near the anesthesiologist, projects the image from the camera, which is shooting directly into the patient’s face in real time. The role of this system is to provide anesthesiologists with a monitoring device that will allow direct and continuous visual access to the patient’s eyes and pressure-sensitive facial structures during prone-position procedures from above the patient by simply looking at the LCD monitor. This can even be used when drapes are placed over the patient’s head or lights are turned off during surgery. Another advantage of this monitoring system is that it allows close monitoring regardless of the particular setup of the OR and equipment. For example, this system works when the anesthesiologist and anesthesia equipment are located facing the patient’s feet, impeding immediate access to the patient’s head.

The Department of Anesthesiology at The Ohio State University Medical Center has been using the ProneView Video Camera Monitoring System for most patients who undergo general anesthesia during surgery in the prone position. The LCD monitor is attached to the Jackson tables to facilitate its use during these cases. This strategic setup of the LCD monitor allows for the easy and continuous monitoring of the patient’s head, eyes, nose, mouth, and pressure-sensitive structures in real time. This ensures that a safe position is maintained and that the endotracheal tube is not displaced during each case, confirming the advantages of this new intraoperative monitoring technique for these types of surgeries. According to our experience at the Ohio State University Medical Center, the use of this new monitoring system has been a positive experience; it is user-friendly and easily installed. At our institution, we consider it to be a promising device for the prevention of POVL and other related prone-position facial injuries because it shows a current and clear image of the face position. It also allows anesthesiologists to monitor inadvertent head movement closely, and therefore to make immediate adjustments to reposition the head in the cushion and ProneView helmet as needed. Although we recommend that further studies be done to confirm the
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utility and advantages of this device, its use in our hospital setting has not only been advantageous but reassuring as well.

Conclusions
Postoperative visual loss seems to be a multifactorial problem with unclear pathophysiological mechanisms. Ocular compression is a critical factor, and eliminating any obvious compression to the eye will help in preventing this devastating perioperative complication. There are only very limited guidelines or protocols on perioperative practice for prone-position surgeries. However, new devices have been designed to prevent mechanical ocular compression during surgical procedures in the prone position. However, these devices do not currently allow anesthesiologists to optimize the position of the head according to the facial surface pressure points and to ensure that all pressure-sensitive structures are placed correctly during surgery while the patient is in the prone position. Developing new devices that include simple surface pressure measurements will potentially allow anesthesiologists to minimize the incidence of devastating postoperative complications, including POVL, in prone-position procedures.

Disclosure
The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

Author contributions to the study and manuscript preparation include the following. Conception and design: Bergese, Uribe, Baig, Puente, Mendel. Acquisition of data: Uribe, Viloria. Analysis and interpretation of data: Uribe, Mendel. Drafting the article: Uribe. Critically revising the article: all authors. Administrative/technical/material support: Bergese, Uribe, Viloria. Study supervision: Uribe.

Acknowledgment
The authors acknowledge Keri Hudec, technical editor at The Ohio State University Medical Center Department of Anesthesiology.

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Accepted August 24, 2009.
Please include this information when citing this paper: DOI: 10.3171/2009.8.FOCUS09151.
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