Anesthesiology 2006; 104:1319–28

Practice Advisory for Perioperative Visual Loss Associated with Spine Surgery

A Report by the American Society of Anesthesiologists Task Force on Perioperative Blindness

PRACTICE advisories are systematically developed reports that are intended to assist decision making in areas of patient care. Advisories provide a synthesis and analysis of expert opinion, clinical feasibility data, open forum commentary, and consensus surveys. Advisories are not intended as standards, guidelines, or absolute requirements. They may be adopted, modified, or rejected according to clinical needs and constraints.

The use of practice advisories cannot guarantee any specific outcome. Practice advisories summarize the state of the literature and report opinions derived from a synthesis of task force members, expert consultants, open forums, and public commentary. Practice advisories are not supported by scientific literature to the same degree as standards or guidelines because of the lack of sufficient numbers of adequately controlled studies. Practice advisories are subject to periodic revision as warranted by the evolution of medical knowledge, technology, and practice.

Methodology

A. Definition of Perioperative Visual Loss

For this Advisory, *perioperative visual loss* refers to permanent impairment or total loss of sight associated with a spine procedure during which general anesthesia is administered. The perioperative period includes the time period from the immediate preoperative assessment through discharge from the acute healthcare facility. The conditions addressed in this advisory are posterior ischemic optic neuropathy [ION], anterior ION, and central retinal artery occlusion (CRAO). "High-risk patients" are defined as those who undergo spine procedures while positioned prone and who have prolonged procedures, experience substantial blood loss, or both.

B. Purposes of the Advisory

The purposes of this advisory are to enhance awareness of perioperative visual loss and reduce its frequency.

C. Focus

This Advisory focuses on the perioperative management of patients who are undergoing spine procedures while they are positioned prone and receiving general anesthesia. This Advisory does not address the perioperative management of patients who receive regional anesthesia or sedation. This Advisory also does not include other causes of visual loss, such as cortical blindness. It does not include nonspine surgical procedures (*e.g.*, cardiac surgery, radical neck dissection). In addition, this advisory does not apply to young children because of the rarity of visual loss in children younger than 12 yr undergoing spine surgery.

D. Application

This Advisory is intended for use by anesthesiologists, spine surgeons, and all other individuals who deliver or who are responsible for anesthesia or perioperative care. These individuals may include orthopedic surgeons, neurosurgeons, ophthalmologists, neuro-ophthalmologists, neurologists, nurse anesthetists, perioperative nurses, and anesthesiology assistants. The Advisory may also serve as a resource for other physicians, nurses, and healthcare professionals who manage anesthetized patients.

E. Task Force Members and Consultants

The American Society of Anesthesiologists (ASA) appointed a Task Force of 12 members to (1) review and assess currently available scientific literature, (2) obtain expert consensus and public opinion, and (3) develop a practice advisory. The Task Force members consisted of

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Developed by the American Society of Anesthesiologists Task Force on Perioperative Blindness: Mark A. Warner, M.D. (Chair), Rochester, Minnesota; James F. Arens, M.D., Houston, Texas; Richard T. Connis, Ph.D., Woodinville, Washington; Karen B. Domino, M.D., Seattle, Washington; Lorri A. Lee, M.D., Seattle, Washington; Neil Miller, M.D., Baltimore, Maryland; Sohail Mirza, M.D., Seattle, Washington; Nancy Newman, M.D., Atlanta, Georgia; David G. Nickinovich, Ph.D., Bellevue, Washington; Steven Roth, M.D., Chicago, Illinois; Peter Savino, M.D., Philadelphia, Pennsylvania; Philip Weinstein, M.D., San Francisco, California.

Submitted for publication November 2, 2005. Accepted for publication November 2, 2005. Supported by the American Society of Anesthesiologists under the direction of James F. Arens, M.D., Chair, Committee on Practice Parameters. Approved by the House of Delegates on October 25, 2005. A list of references used to develop this Advisory is available by writing to the American Society of Anesthesiologists. This Advisory has been endorsed by the North American Neuro-Ophthalmology Society and supported by the North American Spine Society.

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four anesthesiologists from various geographic areas of the United States, three neuro-ophthalmologists (one neurologist, two ophthalmologists), an orthopedic spine surgeon, a neurosurgeon, and two methodologists from the ASA Committee on Practice Parameters. Three physicians served as official liaisons from national organizations. They included a neuro-ophthalmologist (North American Neuro-Ophthalmology Society [NANOS]), an orthopedic surgeon (American Academy of Orthopedic Surgery), and a neurosurgeon (American Association of Neurologic Surgeons).

The Task Force used a six-step process. First, it reached consensus on the criteria for evidence of effective perioperative interventions for the prevention of visual loss. Second, original published articles from peer-reviewed journals relevant to these issues were evaluated. Third, consultants who had expertise or interest in perioperative visual loss and who practiced or worked in various settings (*e.g.*, academic and private practice) were asked to (1) participate in opinion surveys on the effectiveness of various perioperative management strategies and (2) review and comment on a draft of the Advisory developed by the Task Force. Fourth, additional opinions were solicited from active members of the Society for Neurosurgical Anesthesia and Critical Care (SNACC), NANOS, and the North American Spine Society (NASS). Fifth, the Task Force held an open forum at a national anesthesia meeting to solicit input on the key concepts of this Advisory. Sixth, all available information was used to build consensus within the Task Force on the Advisory.

The draft document was made available for review on the ASA Web site, and input was invited *via* e-mail announcement to all ASA members. All submitted comments were considered by the Task Force in preparing the final draft.

F. Availability and Strength of Evidence

Practice advisories are developed by a protocol similar to that of an ASA evidence-based practice guideline, including a systematic search and evaluation of the literature. However, practice advisories lack the support of a sufficient number of adequately controlled studies to permit aggregate analyses of data with rigorous statistical techniques such as meta-analysis. Nonetheless, literature-based evidence from case reports and other descriptive studies are considered during the development of the Advisory. This literature often permits the identification of recurring patterns of clinical practice.

As with a practice guideline, formal survey information is collected from consultants and members of the ASA. The following terms describe survey responses for any specified issue. Responses are solicited from four response categories: agree, equivocal, disagree, and no opinion. Survey information is summarized in the text based on modal responses (*e.g.*, a modal response of "agree" will be listed in the text as an agreement).

Additional information is obtained from open forum presentations and other invited and public sources. The advisory statements contained in this document are a distillation of the current spectrum of clinical opinion and literature-based findings.

Advisories

I. Preoperative Patient Evaluation and Preparation

Visual loss after spine surgery is an uncommon occurrence.[1–3] Ophthalmic complications, including posterior ION, anterior ION, and CRAO, have been reported to occur in less than 0.2% of spine surgeries.[4–6] There are no clinical trials addressing the impact of performing a focused preoperative evaluation for perioperative visual loss.* However, one case–control study and several case reports suggest that preoperative anemia and vascular risk factors such as hypertension, glaucoma, carotid artery disease, smoking, obesity, and diabetes may be associated with perioperative visual loss.[7–12] The literature also suggests an association of perioperative visual loss with prolonged procedures, substantial blood loss, or both.[4,6–22]

The consultants and specialty society members disagree that an ophthalmic or neuro-ophthalmic evaluation is effective in identifying patients at risk for perioperative visual loss. The consultants and specialty society members agree that vascular risk factors increase the risk of perioperative visual loss. In addition, they agree that (1) the preoperative presence of anemia, (2) prolonged procedures, (3) substantial blood loss, and (4) prolonged procedures combined with substantial blood loss all increase the risk of perioperative visual loss. The consultants and specialty society members consider procedures to be prolonged when they exceed an average of 6.5 h (range, 2–12 h) in duration. They consider blood loss to be substantial when the loss reaches an average of 44.7% (range, 10–200%) of estimated blood volume.

Advisory. Although the consultants and specialty society members agree that there are identifiable preoperative risk factors, at this time the Task Force does not believe that there are identifiable preoperative patient characteristics that predispose patients to perioperative ION. Further, the Task Force believes that there is no evidence that an ophthalmic or neuro-ophthalmic evaluation would be useful in identifying patients at risk for perioperative visual loss. The Task Force does, however, believe that the risk of perioperative ION may be increased in patients who undergo prolonged procedures, have substantial blood loss, or both. For the purposes of this advisory, the Task Force considers such patients (hereafter referred to as "high-risk patients") to have a

* Refer to appendix for details of the literature review and data analyses.

higher risk for perioperative visual loss than patients who do not undergo prolonged procedures, have substantial blood loss, or both. Consider informing patients in whom prolonged procedures, substantial blood loss, or both are anticipated that there is a small, unpredictable risk of perioperative visual loss. Because the frequency of visual loss after spine surgery of short duration is very low, the decision to inform patients who are *not* anticipated to be "high risk" for visual loss should be determined on a case-by-case basis.

II. Intraoperative Management

A number of intraoperative factors have been proposed to be associated with perioperative visual loss in patients undergoing spine surgery. These include hypotension, blood loss, anemia, hypovolemia, hypoxia, hemodilution, facial edema, pressure on the eye, use of vasopressors, prone and head-down positions, substantial fluid resuscitation, increased venous pressures, and prolonged surgery. Among these factors, only prolonged surgical duration and substantial blood loss have been present in a majority of patients who have experienced perioperative visual loss.[7]

1. Blood Pressure Management. Blood pressure management of high-risk patients depends on multiple patient characteristics such as the preoperative presence of chronic hypertension, cardiac dysfunction, and renal and vascular disease. In addition, there are many intraoperative factors, such as fluid management, rate of blood loss, use of deliberate hypotension, and administration of vasopressors, that impact blood pressure management. Several case reports have reported perioperative visual loss after procedures in which substantial blood loss and hypotension occurred.[9,15–17,21,23]

The consultants and specialty society members disagree with the survey statement "Deliberate hypotension techniques may be used in high-risk patients" (*i.e.*, for high-risk patients without preoperative chronic hypertension *or* for high-risk patients with well-controlled preoperative chronic hypertension). However, NASS members are equally split in their opinions between agree and disagree for patients *without* preoperative chronic hypertension. Consultants and specialty society members who agree that deliberate hypotension may be used in patients *without* preoperative chronic hypertension indicate that blood pressure should be maintained on average within 24% (range, 0–40%) of estimated baseline mean arterial pressure or with a minimum systolic blood pressure of 84 mmHg (range, 50–120 mmHg).

Advisory. Systemic blood pressure should be continually monitored in high-risk patients. The Task Force believes that the use of deliberate hypotensive techniques during spine surgery has not been shown to be associated with the development of perioperative visual loss. Therefore, the use of deliberate hypotension for these patients should be determined on a case-by-case basis.

2. Management of Intraoperative Fluids. No studies were found that examined the impact of monitoring intravascular volume on the occurrence of visual loss among spine surgery patients. The consultants and specialty society members agree that intravascular volume should be continually monitored in high-risk patients. Although the use of large volumes of crystalloids has been shown to be associated with increased intraoperative ocular pressure, periorbital edema, and double vision,[24] no studies were found that addressed these issues in spine surgery patients. The consultants, SNACC members, and NANOS members agree that the balance between colloid and crystalloid fluid resuscitation and replacement has an impact on the potential for perioperative vision loss; the NASS members report no opinion. The consultants and SNACC members are equivocal regarding the preference of colloids over crystalloids for fluid resuscitation and replacement to reduce the potential for perioperative vision loss; the NANOS and NASS members report no opinion. The consultants, SNACC members, and NASS members agree that central venous pressure monitoring should be used in high-risk patients; the NANOS members report no opinion.

Advisory. Colloids should be used along with crystalloids to maintain intravascular volume in patients who have substantial blood loss. Central venous pressure monitoring should be considered in high-risk patients.

3. Management of Anemia. No prospective studies were found that examined the intraoperative management of anemia during spine surgery. One retrospective comparison of patients who experienced perioperative visual loss after spine surgery with a matched control group found no difference in lowest recorded hematocrit values between groups.[7] The consultants and specialty society members agree that hemoglobin or hematocrit levels should be periodically monitored to detect anemia in high-risk patients. Those who agree indicate that intraoperative hemoglobin or hematocrit should be maintained at a minimum average of 9.4 g/dl (range, 6–13 g/dl) or 28% (range, 18–37%), respectively.

Advisory. Hemoglobin or hematocrit levels should be periodically monitored during surgery in high-risk patients who experience substantial blood loss. The Task Force believes that there is no documented lower limit of hemoglobin concentration that has been associated with the development of perioperative visual loss. Therefore, the Task Force believes a transfusion threshold that would eliminate the risk of perioperative visual loss related to anemia cannot be established at this time.

4. Vasopressors. No studies were found that examined the prolonged use of high-dose α-adrenergic agonists during spine surgery. The SNACC members agree that prolonged use of high-dose α-adrenergic agonists may reduce perfusion of the optic nerve in high-risk patients; the consultants are equivocal, and the NANOS and NASS members report no opinion.

Advisory. The Task Force consensus is that there is insufficient evidence to provide guidance for the use of α-adrenergic agonists in high-risk patients during spine surgery. Therefore, the decision to use α-adrenergic agonists should be made on a case-by-case basis.

5. Patient Positioning. Several case reports suggest that direct pressure to eyes from the use of a sheet roll or headrest results in acute-onset ION or CRAO in spine surgery patients.[17,23,25–31] However, cases of perioperative visual loss also have been reported after patient head positioning without the use of a sheet roll or headrest (*e.g.*, head held with pins).[13,17] The consultants and specialty society members agree that direct pressure on the eye should be avoided to reduce the risk of CRAO and other ocular damage. The consultants and SNACC members agree that the patient's head should be positioned level with or higher than the heart in high-risk patients; NANOS member opinion is equally split between agree and equivocal; and NASS member opinion is equally split among agree, equivocal, and no opinion. The consultants, SNACC members, and NASS members agree that the patient's head should be placed in a neutral forward position in high-risk patients; the NANOS members report no opinion. The consultants, SNACC members, and NANOS members agree that the type of head positioning device is not associated with perioperative ION; the NASS members disagree. The consultants and all specialty society members agree that the use of a horseshoe headrest may increase the risk of ocular compression and perioperative CRAO. They all agree that the eyes of prone-positioned patients should be regularly assessed and documented. In addition, they all agree that perioperative facial edema is common in high-risk patients.

Advisory. The Task Force believes that there is no pathophysiologic mechanism by which facial edema can cause perioperative ION. There is no evidence that ocular compression causes isolated perioperative anterior ION or posterior ION. However, direct pressure on the eye should be avoided to prevent CRAO. The high-risk patient should be positioned so that the head is level with or higher than the heart when possible. The high-risk patient's head should be maintained in a neutral forward position (*e.g.*, without significant neck flexion, extension, lateral flexion, or rotation) when possible.

6. Surgical Procedures. The majority of spine surgery patients who have development of perioperative ION undergo prolonged procedures with substantial blood loss while they are positioned prone. Although no studies were found that examined the impact of surgical staging on reducing the frequency of perioperative visual loss, one retrospective study reported an association between duration of anesthesia and frequency of eye injury after nonocular surgery.[22] The consultants and specialty society members agree that consideration should be given to staging procedures that are anticipated to be lengthy. Members of the specialty societies agree with the staging of procedures that are anticipated to have substantial blood loss; consultant opinion is equally split between agree and equivocal. All groups agree with the staging of procedures that are anticipated to be lengthy and have substantial blood loss. The consultants and specialty society members consider procedures to be prolonged when they exceed an average 6.5 h (range, 2–12 h) in duration. They consider blood loss to be substantial when the loss reaches an average of 44.7% (range, 10–200%) of estimated blood volume.

Advisory. Although the use of staged spine surgery procedures in high-risk patients may entail additional costs and patient risks (*e.g.*, infection, thromboembolism, neurologic injury), it also may decrease these risks and the risk of perioperative visual loss in some patients. Therefore, consideration should be given to the use of staged spine procedures in high-risk patients.

III. Postoperative Management

No studies were found that examined the use of magnetic resonance imaging to assess the extent of visual loss after spine surgery in patients with posterior ION. However, the consultants and specialty society members agree that magnetic resonance imaging may be useful to detect causes of visual loss other than ION and CRAO (*e.g.*, cortical blindness, pituitary apoplexy). All groups agree that a high-risk patient's vision should be assessed when the patient becomes alert. No studies were found that examined the impact of maintaining increased postoperative hematocrit and blood pressure on recovery of visual loss. Nevertheless, the consultants and specialty society members agree that, in high-risk patients for whom ION is suspected, hemoglobin or hematocrit levels should be adjusted upward, blood pressure should be increased, and oxygen should be administered.

Although one case report was found that described the use of a 1-week course of high-dose steroids to treat a patient with ION after lumbar spinal fusion, no vision improvement was noted.[21] No studies were found that addressed the use of antiplatelet agents or intraocular pressure–lowering agents in the treatment of ION. The consultants and SNACC members are equivocal, NANOS member opinion is equally split between agree and equivocal, and the NASS members report no opinion regarding the statement that there is no role for steroids, antiplatelet agents, or intraocular pressure–lowering agents in the treatment of perioperative ION. All groups agree that there is no proven treatment for perioperative ION.

Advisory. The consensus of the Task Force is that a high-risk patient's vision should be assessed when the patient becomes alert (*e.g.*, in the recovery room, intensive care unit, or nursing floor). If there is concern regarding potential visual loss, an urgent ophthalmologic consultation should be obtained to determine its cause.

Table 1. Summary of the Advisory

- There is a subset of patients who undergo spine procedures while they are positioned prone and receiving general anesthesia that has an increased risk for development of perioperative visual loss. This subset includes patients who are anticipated preoperatively to undergo procedures that are prolonged, have substantial blood loss, or both (high-risk patients).
- Consider informing high-risk patients that there is a small, unpredictable risk of perioperative visual loss.
- The use of deliberate hypotensive techniques during spine surgery has not been shown to be associated with the development of perioperative visual loss.
- Colloids should be used along with crystalloids to maintain intravascular volume in patients who have substantial blood loss.
- At this time, there is no apparent transfusion threshold that would eliminate the risk of perioperative visual loss related to anemia.
- High-risk patients should be positioned so that their heads are level with or higher than the heart when possible. In addition, their heads should be maintained in a neutral forward position (*e.g.*, without significant neck flexion, extension, lateral flexion, or rotation) when possible.
- Consideration should be given to the use of staged spine procedures in high-risk patients.

Additional management may include optimizing hemoglobin or hematocrit levels, hemodynamic status, and arterial oxygenation. To rule out intracranial causes of visual loss, consider magnetic resonance imaging. The Task Force believes that there is no role for antiplatelet agents, steroids, or intraocular pressure–lowering agents in the treatment of perioperative ION.

Summary

The primary findings of the Task Force are shown in table 1. They have been developed to provide advice on the perioperative care of patients who are undergoing spine procedures while they are positioned prone and receiving general anesthesia.

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Appendix. Literature Review and Consensus-based Evidence

A. State of the Literature

For this Advisory, a literature review was used in combination with opinions obtained from experts and other sources (*e.g.*, professional society members, open forums, Web-based postings) to provide guidance to practitioners regarding the perioperative management of patients undergoing spine procedures who may be at risk of perioperative visual loss. Both the literature review and opinion data were based on *evidence linkages*, consisting of directional statements about relationships between specific perioperative management activities (*i.e.*, associated with a spine procedure during which general anesthesia is administered) and permanent impairment or total loss of sight. The interventions for the evidence linkages are listed below:

Preoperative Patient Evaluation and Preparation

Ophthalmic or neuro-ophthalmic evaluation
Vascular risk factors
Preoperative anemia
Prolonged procedures
Substantial blood loss
Prolonged procedures combined with substantial blood loss

Intraoperative Management

Blood pressure management
  Deliberate hypotension techniques in *high-risk* patients *without* preoperative chronic hypertension

Deliberate hypotension techniques in *high-risk* patients *with* well-controlled preoperative chronic hypertension
Management of intraoperative fluids
Continual intravascular volume monitoring for *high-risk* patients
Central venous pressure monitoring for *high-risk* patients
Colloid and crystalloid balance for fluid resuscitation
Colloids *versus* crystalloids for fluid resuscitation and replacement
Management of anemia
Periodic monitoring of hemoglobin or hematocrit levels
Vasopressors
Prolonged use of high-dose α-adrenergic agonists in *high-risk* patients
Patient positioning
Avoidance of direct pressure on the eye
Positioning of head level with or higher than the heart in *high-risk* patients
Placing head in a neutral forward position in *high-risk* patients
Type of head positioning device
Use of a horseshoe headrest
Regular assessment and documentation of the eyes of prone-positioned patients
Occurrence of perioperative facial edema in *high-risk* patients
Surgical procedures
Staging of procedures anticipated to be lengthy
Staging of procedures anticipated to have substantial blood loss
Staging of procedures anticipated to be lengthy with substantial blood loss

Postoperative Management

Assessing a *high-risk* patient's vision when the patient becomes alert
Magnetic resonance imaging
Adjusting hemoglobin or hematocrit levels upward in patients for whom ION is suspected
Increasing blood pressure in patients for whom ION is suspected
Administering arterial oxygenation in patients for whom ION is suspected
Administering antiplatelet agents, steroids, or intraocular pressure–lowering agents

A study or report that appears in the published literature is included in the development of an advisory if the study (1) is related to one of the specified linkage statements, (2) reports a finding or set of findings that can be tallied or measured (*e.g.*, articles that contain only opinion are not included), and (3) is the product of an original investigation or report (*i.e.*, review articles or follow-up studies that summarize previous findings are not included).

Although evidence linkages are designed to assess causality, few of the reviewed studies exhibited sufficiently acceptable quantitative methods and analyses to provide a clear indication of causality. Therefore, the published literature could not be used as a source of quantitative support (required for the development of practice guidelines). However, many published studies were evaluated that provided the Task Force with important noncausal evidence. For example, descriptive literature (*i.e.*, reports of frequency or incidence) is often useful in providing an indication of the scope of a problem, and case reports may be useful in identifying perioperative events that may be precursors to permanent visual impairment or total loss of sight.

For the literature review, potentially relevant studies were identified *via* electronic and manual searches of the literature. The electronic search covered a 40-yr period from 1966 through 2005. The manual search covered a 73-yr period from 1933 through 2005. More than 500 citations were initially identified, yielding a total of 451 nonoverlapping articles that addressed topics related to the evidence linkages. After review of the articles, 424 studies did not provide direct evidence and were subsequently eliminated. A total of 27 articles contained direct linkage-related evidence. No evidence linkage contained enough studies with well-defined experimental designs and statistical information to conduct a quantitative analysis (*i.e.*, meta-analysis).

Interobserver agreement among Task Force members and two methodologists was established by interrater reliability testing. Agreement levels using a kappa (κ) statistic for two-rater agreement pairs were as follows: (1) type of study design, $\kappa = 0.64–0.78$; (2) type of analysis, $\kappa = 0.74–0.87$; (3) evidence linkage assignment, $\kappa = 0.69–0.94$; and (4) literature inclusion for database, $\kappa = 0.77–1.00$. Three-rater chance-corrected agreement values were (1) study design, Sav = 0.69, Var (Sav) = 0.022; (2) type of analysis, Sav = 0.82, Var (Sav) = 0.017; (3) linkage assignment, Sav = 0.79, Var (Sav) = 0.007; and (4) literature database inclusion, Sav = 0.86, Var (Sav) = 0.030. These values represent moderate to high levels of agreement.

B. Consensus-based Evidence

Consensus was obtained from multiple sources, including (1) survey opinion from consultants who were selected based on their knowledge or expertise regarding perioperative visual impairment or total loss of sight associated with a spine procedure during which general anesthesia is administered; (2) survey opinions from selected samples of active members of SNACC, NANOS, and NASS; (3) testimony from attendees of a publicly held open forum at a national anesthesia meeting†; (4) Internet commentary; and (5) Task Force opinion and interpretation. The consultant survey rate of return was 60% (n = 18 of 30). Survey results are presented in the text of the document and in tables 2–5.

† 20th Annual Meeting of the Society of Ambulatory Anesthesia, May 13, 2005, Scottsdale, Arizona.

Table 2. Consultant Survey: Percentage Responses

Evidence Linkage/Intervention	n	Agree	Equivocal	Disagree	No Opinion
1. Preoperative patient evaluation and preparation					
Ophthalmic or neuro-ophthalmic evaluation	18	16.7	33.3	44.4*	5.6
Vascular risk factors	18	77.8*	5.6	5.6	11.1
Preoperative anemia	18	50.0*	27.8	16.9	5.6
Prolonged procedures	18	100.0*	0.0	0.0	0.0
Substantial blood loss	18	88.9*	11.1	0.0	0.0
Prolonged procedures combined with substantial blood loss	18	94.4*	5.6	0.0	0.0
2. Intraoperative blood pressure management					
Deliberate hypotension in *high-risk* patients *without* preoperative chronic hypertension	18	22.2	33.3	44.4*	0.0
Deliberate hypotension in *high-risk* patients *with* well-controlled preoperative chronic hypertension	18	5.6	38.9	55.6*	0.0
3. Management of intraoperative fluids					
Intravascular volume should be continually monitored in *high-risk* patients	17	64.7*	35.3	0.0	0.0
Balance between colloid and crystalloid fluid resuscitation and replacement	18	38.9*	27.8	27.8	5.6
Colloids are preferred over crystalloids	18	22.2	44.4*	27.8	5.6
CVP monitoring for *high-risk* patients	18	38.9*	33.3	22.2	5.6
4. Management of anemia					
Periodic monitoring of Hgb or Hct for *high-risk* patients	17	100.0*	0.0	0.0	0.0
5. Vasopressors					
Prolonged use of high-dose α-adrenergic agonists in *high-risk* patients	18	27.8	50.0*	5.6	16.7
6. Patient positioning					
Avoid direct pressure on the eye	18	100.0*	0.0	0.0	0.0
Head position level with or higher than the heart in *high-risk* patients	18	61.1*	22.2	5.6	11.1
Neutral forward position of head in *high-risk* patients	17	47.1*	41.2	5.9	5.9
Head positioning device *not* associated with AION or PION	18	83.3*	16.7	0.0	0.0
Horseshoe headrest may increase ocular compression and perioperative CRAO	18	83.3*	11.1	5.6	0.0
Regular assessment and documentation of eyes of prone-positioned patients	18	88.9*	5.6	5.6	0.0
Perioperative facial edema is common in *high-risk* patients	17	76.5*	0.0	23.5	0.0
7. Surgical procedures					
Staging of lengthy procedures	18	50.0*	44.4	0.0	5.6
Staging of procedures with substantial blood loss	18	44.4*	44.4*	0.0	11.1
Staging of lengthy procedures with substantial blood loss	18	66.7*	27.8	0.0	5.6
8. Postoperative management					
Assessment of *high-risk* patient's vision when the patient becomes alert	18	83.3*	16.7	0.0	0.0
No proven treatment for perioperative AION or PION	18	77.8*	11.1	5.6	5.6
MRI to eliminate causes other than ION and CRAO	18	77.8*	0.0	5.6	16.7
In *high-risk* patients for whom ION is suspected, adjust Hgb or Hct levels upward, increase blood pressure, and administer arterial oxygenation	17	76.5*	23.5	0.0	0.0
No role for antiplatelet agents, steroids, or intraocular pressure–lowering agents in the treatment of perioperative ION	17	35.3	52.9*	5.9	5.9

* Modal response.

AION = anterior ischemic optic neuropathy; CRAO = central retinal artery occlusion; CVP = central venous pressure; Hgb = hemoglobin; Hct = hematocrit; ION = ischemic optic neuropathy; MRI = magnetic resonance imaging; n = number of consultants who responded to each item; PION = posterior ischemic optic neuropathy.

Table 3. Society for Neurosurgical Anesthesia and Critical Care Member Survey: Percentage Responses

Evidence Linkage/Intervention	n	Agree	Equivocal	Disagree	No Opinion
1. Preoperative patient evaluation and preparation					
Ophthalmic or neuro-ophthalmic evaluation	126	16.7	27.8	39.7*	15.9
Vascular risk factors	127	74.8*	16.5	3.1	5.5
Preoperative anemia	127	55.9*	26.0	13.4	4.7
Prolonged procedures	127	85.0*	9.4	2.4	3.1
Substantial blood loss	126	84.1*	9.5	4.8	1.6
Prolonged procedures combined with substantial blood loss	126	90.5*	6.3	1.6	1.6
2. Intraoperative blood pressure management					
Deliberate hypotension in *high-risk* patients *without* preoperative chronic hypertension	127	19.7	16.5	59.8*	3.9
Deliberate hypotension in *high-risk* patients *with* well-controlled preoperative chronic hypertension	127	17.3	16.5	63.0*	3.1
3. Management of intraoperative fluids					
Intravascular volume should be continually monitored in *high-risk* patients	127	66.9*	22.0	9.4	1.6
Balance between colloid and crystalloid fluid resuscitation and replacement	127	29.9*	29.1	28.3	12.6
Colloids are preferred over crystalloids	127	22.0	35.4*	34.6	7.9
CVP monitoring for *high-risk* patients	127	41.7*	33.1	23.6	1.6
4. Management of anemia					
Periodic monitoring of Hgb or Hct for *high-risk* patients	127	93.7*	4.7	0.8	0.8
5. Vasopressors					
Prolonged use of high-dose α-adrenergic agonists in *high-risk* patients	126	37.3*	36.5	13.5	12.7
6. Patient positioning					
Avoid direct pressure on the eye	127	99.2*	0.0	0.8	0.0
Head position level with or higher than the heart in *high-risk* patients	127	51.2*	26.8	12.6	9.4
Neutral forward position of head in *high-risk* patients	124	75.8*	11.3	5.6	7.3
Head positioning device *not* associated with AION or PION	126	38.1*	15.9	35.7	10.3
Horseshoe headrest may increase ocular compression and perioperative CRAO	125	46.4*	21.6	20.8	11.2
Regular assessment and documentation of eyes of prone-positioned patients	126	90.5*	4.0	4.0	1.6
Perioperative facial edema is common in *high-risk* patients	125	77.6*	10.4	7.2	4.8
7. Surgical procedures					
Staging of lengthy procedures	126	61.9*	23.0	11.1	4.0
Staging of procedures with substantial blood loss	126	65.1*	19.8*	11.1	4.0
Staging of lengthy procedures with substantial blood loss	126	73.8*	17.5	5.6	3.2
8. Postoperative management					
Assessment of *high-risk* patient's vision when the patient becomes alert	127	86.6*	11.0	0.8	1.6
No proven treatment for perioperative AION or PION	127	67.7*	14.2	5.5	12.6
MRI to eliminate causes other than ION and CRAO	127	62.2*	16.5	3.1	18.1
In *high-risk* patients for whom ION is suspected, adjust Hgb or Hct levels upward, increase blood pressure, and administer arterial oxygenation	128	77.3*	16.4	1.6	4.7
No role for antiplatelet agents, steroids, or intraocular pressure–lowering agents in the treatment of perioperative ION	128	28.1	42.2*	7.8	21.9

* Modal response.

AION = anterior ischemic optic neuropathy; CRAO = central retinal artery occlusion; CVP = central venous pressure; Hgb = hemoglobin; Hct = hematocrit; ION = ischemic optic neuropathy; MRI = magnetic resonance imaging; n = number of Society for Neurosurgical Anesthesia and Critical Care members who responded to each item; PION = posterior ischemic optic neuropathy.

Table 4. North American Neuro-Ophthalmology Society Member Survey: Percentage Responses

Evidence Linkage/Intervention	n	Agree	Equivocal	Disagree	No Opinion
1. Preoperative patient evaluation and preparation					
Ophthalmic or neuro-ophthalmic evaluation	32	15.6	40.6	43.8*	0.0
Vascular risk factors	30	83.3*	10.0	6.7	0.0
Preoperative anemia	32	75.0*	12.5	12.5	0.0
Prolonged procedures	32	81.3*	15.6	3.1	0.0
Substantial blood loss	32	96.9*	3.1	0.0	0.0
Prolonged procedures combined with substantial blood loss	32	93.8*	6.3	0.0	0.0
2. Intraoperative blood pressure management					
Deliberate hypotension in *high-risk* patients *without* preoperative chronic hypertension	31	12.9	19.4	41.9*	25.8
Deliberate hypotension in *high-risk* patients *with* well-controlled preoperative chronic hypertension	31	12.9	12.9	48.4*	25.8
3. Management of intraoperative fluids					
Intravascular volume should be continually monitored in *high-risk* patients	30	80.0*	3.3	0.0	16.7
Balance between colloid and crystalloid fluid resuscitation and replacement	30	43.3*	13.3	3.3	40.0
Colloids are preferred over crystalloids	29	31.0	17.2	0.0	51.7*
CVP monitoring for *high-risk* patients	29	30.1	17.2	0.0	51.7*
4. Management of anemia					
Periodic monitoring of Hgb or Hct for *high-risk* patients	31	83.9*	9.7	0.0	6.5
5. Vasopressors					
Prolonged use of high-dose α-adrenergic agonists in *high-risk* patients	31	38.7	12.9	3.2	45.2*
6. Patient positioning					
Avoid direct pressure on the eye	31	96.8*	3.2	0.0	0.0
Head position level with or higher than the heart in *high-risk* patients	31	32.3*	32.3*	6.5	29.0
Neutral forward position of head in *high-risk* patients	30	30.0	26.7	3.3	40.0*
Head positioning device *not* associated with AION or PION	31	32.3*	22.6	29.0	16.1
Horseshoe headrest may increase ocular compression and perioperative CRAO	31	64.5*	9.7	12.9	12.9
Regular assessment and documentation of eyes of prone-positioned patients	31	83.9*	6.5	3.2	6.5
Perioperative facial edema is common in *high-risk* patients	31	67.7*	6.5	9.7	16.1
7. Surgical procedures					
Staging of lengthy procedures	32	50.0*	21.9	6.3	21.9
Staging of procedures with substantial blood loss	31	71.0*	12.9*	6.5	9.7
Staging of lengthy procedures with substantial blood loss	31	71.0*	9.7	6.5	12.9
8. Postoperative management					
Assessment of *high-risk* patient's vision when the patient becomes alert	32	81.3*	9.4	3.1	6.3
No proven treatment for perioperative AION or PION	32	75.0*	15.6	6.3	3.1
MRI to eliminate causes other than ION and CRAO	32	81.3*	12.5	3.1	3.1
In *high-risk* patients for whom ION is suspected, adjust Hgb or Hct levels upward, increase blood pressure, and administer arterial oxygenation	32	90.6*	6.3	3.1	0.0
No role for antiplatelet agents, steroids, or intraocular pressure–lowering agents in the treatment of perioperative ION	31	35.5*	35.5*	22.6	6.5

* Modal response.

AION = anterior ischemic optic neuropathy; CRAO = central retinal artery occlusion; CVP = central venous pressure; Hgb = hemoglobin; Hct = hematocrit; ION = ischemic optic neuropathy; MRI = magnetic resonance imaging; n = number of North American Neuro-Ophthalmology Society members who responded to each item; PION = posterior ischemic optic neuropathy.

Table 5. North American Spine Society Member Survey: Percentage Responses

Evidence Linkage/Intervention	n	Agree	Equivocal	Disagree	No Opinion
1. Preoperative patient evaluation and preparation					
Ophthalmic or neuro-ophthalmic evaluation	20	0.0	20.0	45.0*	35.0
Vascular risk factors	19	52.6*	21.1	10.5	15.8
Preoperative anemia	20	45.0*	15.0	20.0	20.0
Prolonged procedures	20	85.0*	0.0	10.0	5.0
Substantial blood loss	20	75.0*	10.0	10.0	5.0
Prolonged procedures combined with substantial blood loss	20	90.0*	0.0	5.0	5.0
2. Intraoperative blood pressure management					
Deliberate hypotension in *high-risk* patients *without* preoperative chronic hypertension	20	35.0*	15.0	35.0*	15.0
Deliberate hypotension in *high-risk* patients *with* well-controlled preoperative chronic hypertension	20	20.0	25.0	40.0*	15.0
3. Management of intraoperative fluids					
Intravascular volume should be continually monitored in *high-risk* patients	20	90.0*	5.0	5.0	0.0
Balance between colloid and crystalloid fluid resuscitation and replacement	20	30.0	10.0	5.0	55.0*
Colloids are preferred over crystalloids	20	15.0	20.0	5.0	60.0*
CVP monitoring for *high-risk* patients	20	55.0*	15.0	10.0	20.0
4. Management of anemia					
Periodic monitoring of Hgb or Hct for *high-risk* patients	20	95.0*	5.0	0.0	0.0
5. Vasopressors					
Prolonged use of high-dose α-adrenergic agonists in *high-risk* patients	20	30.0	5.0	0.0	65.0*
6. Patient positioning					
Avoid direct pressure on the eye	20	100.0*	0.0	0.0	0.0
Head position level with or higher than the heart in *high-risk* patients	20	30.0*	30.0*	10.0	30.0*
Neutral forward position of head in *high-risk* patients	20	60.0*	15.0	10.0	15.0
Head positioning device *not* associated with AION or PION	20	10.0	10.0	65.0*	15.0
Horseshoe headrest may increase ocular compression and perioperative CRAO	19	73.7*	10.5	10.5	5.3
Regular assessment and documentation of eyes of prone-positioned patients	20	95.0*	0.0	0.0	5.0
Perioperative facial edema is common in *high-risk* patients	20	75.0*	15.0	5.0	5.0
7. Surgical procedures					
Staging of lengthy procedures	20	60.0*	20.0	10.0	10.0
Staging of procedures with substantial blood loss	20	70.0*	20.0	5.0	5.0
Staging of lengthy procedures with substantial blood loss	20	90.0*	10.0	0.0	0.0
8. Postoperative management					
Assessment of *high-risk* patient's vision when the patient becomes alert	20	90.0*	0.0	0.0	10.0
No proven treatment for perioperative AION or PION	20	65.0*	10.0	5.0	20.0
MRI to eliminate causes other than ION and CRAO	20	55.0*	5.0	5.0	35.0
In *high-risk* patients for whom ION is suspected, adjust Hgb or Hct levels upward, increase blood pressure, and administer arterial oxygenation	19	78.9*	5.3	0.0	15.8
No role for antiplatelet agents, steroids, or intraocular pressure–lowering agents in the treatment of perioperative ION	19	0.0	31.6*	5.3	63.2*

* Modal response.

AION = anterior ischemic optic neuropathy; CRAO = central retinal artery occlusion; CVP = central venous pressure; Hgb = hemoglobin; Hct = hematocrit; ION = ischemic optic neuropathy; MRI = magnetic resonance imaging; n = number of North American Spine Society members who responded to each item; PION = posterior ischemic optic neuropathy.