Practice Advisory for Perioperative Visual Loss Associated with Spine Surgery

An Updated Report by the American Society of Anesthesiologists Task Force on Perioperative Visual Loss

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. Practice Advisories developed by the American Society of Anesthesiologists (ASA) are not intended as standards, guidelines, or absolute requirements, and their use cannot guarantee any specific outcome. They may be adopted, modified, or rejected according to clinical needs and constraints and are not intended to replace local institutional policies.

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 update or revision as warranted by the evolution of medical knowledge, technology, and practice.

- What other guideline statements are available on this topic?
  - This Practice Advisory updates the "Practice Advisory for Perioperative Visual Loss Associated with Spine Surgery," adopted by the ASA in 2005 and published in 2006.*
- Why was this Advisory developed?
  - In October 2010, the Committee on Standards and Practice Parameters elected to collect new evidence to determine whether recommendations in the existing Practice Advisory were supported by current evidence.
- How does this Advisory differ from existing guidelines?
  - New evidence presented includes an updated evaluation of scientific literature. The new findings did not necessitate a change in recommendations.
- Why does this Advisory differ from existing guidelines?
  - The ASA advisory differs from the existing guidelines because it provides new evidence obtained from recent scientific literature.

This document updates the "Practice Advisory for Perioperative Visual Loss Associated with Spine Surgery: A Report by the American Society of Anesthesiologists Task Force on Perioperative Blindness," adopted by the ASA in 2005 and published in 2006.*

Methodology

A. Definition of Perioperative Visual loss

Visual loss after spine surgery is an uncommon occurrence.[1–3] Ophthalmic complications have been reported to occur in less than 0.2% of spine surgeries.[4–8] 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. Conditions addressed in this Advisory include 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

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Address correspondence to the American Society of Anesthesiologists: 520 North Northwest Highway, Park Ridge, Illinois 60068-2573. This Practice Advisory, as well as all published ASA Practice Parameters, may be obtained at no cost through the Journal Web site, www.anesthesiology.org.

* American Society of Anesthesiologists Task Force on Perioperative Visual Loss: Practice Advisory for Perioperative Visual Loss Associated with Spine Surgery: A Report by the American Society of Anesthesiologists Task Force on Perioperative Blindness. ANESTHESIOLOGY 2006; 104:1319–28.

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prone and who have prolonged procedures, experience substantial blood loss, or both.

B. Purpose of the Advisory

The purpose of this Advisory is to enhance awareness and reduce the frequency of perioperative visual loss.

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 years of age 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 original Advisory was developed by an ASA-appointed task force of 10 members, consisting of 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 Standards and 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 Orthopaedic Surgeons), and a neurosurgeon (American Association of Neurological Surgeons).

The Task Force developed the original Advisory by means of 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 perioperative visual loss 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 Neuroscience in Anesthesiology 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. A summary of recommendations may be found in appendix 1.

The draft document was made available for review on the ASA website, 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.

In 2009, the ASA Committee on Standards and Practice Parameters requested that scientific evidence for this Advisory be updated. The update consists of an evaluation of literature published after completion of the original Advisory.

F. Availability and Strength of Evidence

Preparation of this update used the same methodological process as was used in the original Advisory to obtain new scientific evidence. Opinion-based evidence obtained from the original Advisory is reported in this update. The protocol for reporting each source of evidence is described below.

G. Scientific Evidence

Study findings from published scientific literature were aggregated and are reported in summary form by evidence category, as described below. All literature (*e.g.*, randomized controlled trials, observational studies, case reports) relevant to each topic was considered when evaluating the findings. However, for reporting purposes in this document, only the highest level of evidence (*i.e.*, level 1, 2, or 3 identified below) within each category (*i.e.*, A, B, or C) is included in the summary.

Category A: Supportive Literature. Randomized controlled trials report statistically significant ($P < 0.01$) differences between clinical interventions for a specified clinical outcome.

Level 1: The literature contains multiple randomized controlled trials, and the aggregated findings are supported by meta-analysis.‡

Level 2: The literature contains multiple randomized controlled trials, but there is an insufficient number of studies to conduct a viable meta-analysis.

Level 3: The literature contains a single randomized controlled trial.

Category B: Suggestive Literature. Information from observational studies permits inference of beneficial or harmful relationships among clinical interventions and clinical outcomes.

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

‡ Practice Advisories lack the support of a sufficient number of adequately controlled studies required to conduct an appropriate meta-analysis. Therefore, Categories A1 and C1 evidence are not reported in this document.

Level 1: The literature contains observational comparisons (*e.g.*, cohort, case-control research designs) of clinical interventions or conditions and indicates statistically significant differences between clinical interventions for a specified clinical outcome.

Level 2: The literature contains noncomparative observational studies with associative (*e.g.*, relative risk, correlation) or descriptive statistics.

Level 3: The literature contains case reports.

Category C: Equivocal Literature. The literature cannot determine whether there are beneficial or harmful relationships among clinical interventions and clinical outcomes.

Level 1: Meta-analysis did not find significant differences among groups or conditions.

Level 2: The number of studies is insufficient to conduct meta-analysis, and (1) randomized controlled trials have not found significant differences among groups or conditions or (2) randomized controlled trials report inconsistent findings.

Level 3: Observational studies report inconsistent findings or do *not* permit inference of beneficial or harmful relationships.

Category D: Insufficient Evidence from Literature. The *lack of scientific* evidence in the literature is described by the following terms.

Inadequate: The available literature cannot be used to assess relationships among clinical interventions and clinical outcomes. The literature either does not meet the criteria for content as defined in the "Focus" of the Advisory or does not permit a clear interpretation of findings due to methodological concerns (*e.g.*, confounding in study design or implementation).

Silent: No identified studies address the specified relationships among interventions and outcomes.

H. Opinion-based Evidence

The original Advisory contained formal survey information collected from expert consultants and samples of active members of the SNACC, NANOS, and the NASS. Additional information was obtained from open forum presentations and other invited and public sources. All opinion-based evidence relevant to each topic (*e.g.*, survey data, open-forum testimony, Internet-based comments, letters, editorials) was considered in the development of the original Advisory. However, only the findings obtained from formal surveys are reported.

Survey responses from Task Force-appointed expert consultants and specialty society members obtained during development of the original Advisory are summarized in the text and reported in appendix 2, tables 1–4.

Responses were 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).

Advisories

I. Preoperative Patient Evaluation and Preparation

There are no clinical trials addressing the impact of performing a focused preoperative evaluation for perioperative visual loss.§ However, two observational studies report that preoperative anemia, vascular risk factors (*e.g.*, hypertension, diabetes, peripheral vascular disease, coronary artery disease), obesity, and tobacco use may be associated with perioperative visual loss (*Category B2 evidence*).[5,9]

Case reports suggest that perioperative visual loss may occur after prolonged procedures[10–17] or substantial intraoperative blood loss[18–25] (*Category B3 evidence*). In addition, observational studies report visual loss among patients undergoing prolonged procedures during which substantial blood loss occurred (*Category B2 evidence*).[5,26,27]

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) 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 for Preoperative Patient Evaluation and Preparation. 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. In addition, 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 believes that the risk of perioperative ION may be increased in patients who 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

Intraoperative management consists of (1) blood pressure management, (2) management of intraoperative fluids, (3)

§ Refer to appendix 2 for details of the literature review and data analyses.

‖ For the purposes of this Advisory, the Task Force considers such patients (hereafter referred to as "high-risk patients") to have a higher risk for perioperative visual loss than patients who do not undergo prolonged procedures, have substantial blood loss, or both.

management of anemia, (4) use of vasopressors, (5) patient positioning, and (6) staging of surgical procedures.

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, hypotension, and administration of vasopressors, that affect blood pressure management. Case reports indicate perioperative visual loss occurring after procedures in which intraoperative hypotension was maintained for patients without hypertension[10,19,20,28–30] or for patients with well-controlled chronic hypertension[30,31] (*Category B3 evidence*).

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 split equally 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 for Blood Pressure Management. Systemic blood pressure should be monitored continually 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.

Management of Intraoperative Fluids. The literature is insufficient to assess the relationship between the monitoring of intravascular volume and the occurrence of visual loss among spine surgery patients (*Category D evidence*). Although the use of large volumes of crystalloids may be associated with increased intraoperative ocular pressure, periorbital edema, and double-vision in patients undergoing cardiopulmonary bypass,[32] the literature is insufficient to address these issues in spine surgery patients (*Category D evidence*).

The consultants, SNACC, NANOS, and NASS members agree that intravascular volume should be monitored continually in high-risk 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 for Management of Intraoperative Fluids. Central venous pressure monitoring should be considered in high-risk patients. Colloids should be used along with crystalloids to maintain intravascular volume in patients who have substantial blood loss.

Management of Anemia. The literature is insufficient to evaluate the efficacy of intraoperative management of anemia during spine surgery (*Category D evidence*). 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[27] (*Category B2 evidence*).

The consultants and specialty society members agree that hemoglobin or hematocrit values should be monitored periodically 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 for Management of Anemia. Hemoglobin or hematocrit values should be monitored periodically 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.

Use of Vasopressors. The literature is insufficient to evaluate the prolonged use of high-dose α-adrenergic agonists during spine surgery (*Category D evidence*). 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 for Use of Vasopressors. 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.

Patient Positioning. Case reports suggest that patient positioning resulting in direct pressure to eyes (*e.g.*, from the use of a headrest, sheet roll, or other device) may precede the onset of CRAO or retinal ischemia in spine surgery patients (*Category B3 evidence*).#[13–16,25,33–42] One observational study indicates that, in 19% of ION cases listed in the ASA Visual Loss Registry, patient head position was maintained with Mayfield pins with the eyes free of pressure[9] (*Category B2 evidence*).

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

Although observational literature on the pathophysiology of retinal vascular occlusion in humans is lacking, animal studies are available.

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 split equally between agree and equivocal, and NASS member opinion is split equally 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, 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 assessed regularly and documented. In addition, they all agree that perioperative facial edema is common in high-risk patients.

Advisory for Patient Positioning. 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.

Staging of Surgical Procedures. The majority of spine surgery patients who experience perioperative ION undergo prolonged procedures with substantial blood loss while they are positioned prone. Although the literature is insufficient to examine the impact of surgical staging on reducing the frequency of perioperative visual loss in spine surgery patients (*Category D evidence*), an observational study indicates that, in 94% of ION cases listed in the ASA Visual Loss Registry, anesthetic duration exceeded 6 h[9] (*Category B2 evidence*). A related retrospective study reported an association between duration of anesthesia and frequency of eye injury after a mix of nonocular surgeries[43] (*Category B2 evidence*).

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 split equally 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 for Staging of Surgical Procedures. Although the use of staged spine surgery procedures in high-risk patients may entail additional costs and patient risks (*e.g.*, infection, thromboembolism, or 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.

IV. Postoperative Management

The literature is insufficient to evaluate the use of magnetic resonance imaging to assess the extent of visual loss after spine surgery in patients with posterior ION (*Category D evidence*). A case report of a spine surgery patient with bilateral POIN indicated that visual recovery occurred after the deliberate maintenance of increased hematocrit and blood pressure (*Category B3 evidence*).[8] One case report found no visual improvement after a 1-week course of high-dose steroids to treat a patient with ION subsequent to lumbar spinal fusion (*Category C3 evidence*).[30] The literature is insufficient to evaluate the use of antiplatelet agents or intraocular pressure-lowering agents in the treatment of ION (*Category D evidence*).

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. The consultants and specialty society members agree that, in high-risk patients for whom ION is suspected, hemoglobin or hematocrit values should be adjusted upward, blood pressure should be increased, and oxygen should be administered.

The consultants and SNACC members are equivocal, NANOS member opinion is split equally between agree and equivocal, and 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 for Postoperative Management. 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. Additional management may include optimizing hemoglobin or hematocrit values, 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.

Appendix 1: Summary of Advisory Statements

I. Preoperative Patient Evaluation and Preparation

- 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 believes that the risk of perioperative ION may be increased in patients who 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

Blood Pressure Management
- Systemic blood pressure should be monitored continually 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.

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

Management of Anemia
- Hemoglobin or hematocrit values should be monitored periodically 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.

Use of Vasopressors
- 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.

Patient Positioning
- 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.

III. Staging of Surgical Procedures

- Although the use of staged spine surgery procedures in high-risk patients may entail additional costs and patient risks (*e.g.*, infection, thromboembolism, or 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.

IV. Postoperative Management

- 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.
- Additional management may include optimizing hemoglobin or hematocrit values, 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.

Appendix 2: Methods and Analyses

A. State of the Literature

For this updated Advisory, a review of studies used in the development of the original Advisory was combined with a review of studies published subsequent to approval of the original Advisory. The updated literature review was based on evidence linkages, consisting of directional statements about relationships between specific perioperative management activities associated with a spine procedure during which general anesthesia is administered and permanent impairment or total loss of sight. The evidence linkage interventions 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

** For the purposes of this Advisory, the Task Force considers such patients to have a higher risk for perioperative visual loss than patients who do not undergo prolonged procedures, have substantial blood loss, or both.

†† Unless otherwise specified, outcomes for the listed interventions refer to the occurrence of perioperative visual loss.

Colloid and crystalloid balance for fluid resuscitation
Colloids *versus* crystalloids for fluid resuscitation and replacement
Management of Anemia
Periodic monitoring of hemoglobin or hematocrit values
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 values 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

For purposes of literature review, potentially relevant clinical studies were identified *via* electronic and manual searches of the literature. The updated electronic search covered a 10-yr period from 2002 through 2011. The manual search covered a 15-yr period of time from 1997 through 2011. More than 100 new citations that addressed topics related to the evidence linkages were identified. These articles were reviewed and combined with pre-2006 articles used in the original Advisory, resulting in a total of 51 articles that contained direct linkage-related evidence.

No evidence linkage contained sufficient literature with well-defined experimental designs and statistical information to conduct an analysis of aggregated studies (*i.e.*, meta-analysis). A complete bibliography used to develop this updated Advisory, organized by section, is available as Supplemental Digital Content 2, http://links.lww.com/ALN/A786.

A study or report that appears in the published literature can be included as evidence in the development of an advisory if it meets four essential criteria. Failure to meet one or more of these criteria means that a study had features that did not make it suitable for analytic purposes. The four essential criteria are as follows: (1) the study must be related to one of the specified linkage statements; (2) the study must report a clinical finding or set of findings that can be tallied or quantified. This criterion eliminates reports that contain only opinion; (3) the study must report a clinical finding or set of findings that can be identified as the product of an original investigation or report. This criterion eliminates the repetitive reporting and counting of the same results, as may occur in review articles or follow-up studies that summarize previous findings, and (4) the study must use sound research methods and analytical approaches that provide a clear test or indication of the relationship between the intervention and outcome of interest. Because none of the studies in this updated Advisory met all four criteria, the published literature could not be used as a source of quantitative support.

Although evidence linkages are designed to assess causality, the reviewed studies did not provide a clear indication of causality. Therefore, the published literature could not be used as a source of quantitative support. 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. In conclusion, the current literature has not been helpful in determining the efficacy of specific perioperative management activities (*i.e.*, associated with a spine procedure during which general anesthesia is administered) in reducing permanent impairment or total loss of sight. Until controlled studies are conducted, evidence from noncausal sources will need to be used, such as consensus-driven data and the opinion of practitioners and experts. It is recommended that future research on perioperative visual loss focus on the identification of patients at higher risk of perioperative visual loss in the context of prospective research designs when feasible.

In the original Advisory, 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. For the updated Advisory, the same two methodologists involved in the original Advisory conducted the literature review.

B. Consensus-based Evidence

For the original Advisory, 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 the 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). Modal survey responses for consultants and specialty group members are presented in the text of the Advisory, and complete listings of survey responses are reported in tables 1–4.

‡‡ Society for Ambulatory Anesthesia 20th Annual Meeting, Scottsdale, Arizona, May 13, 2005.

Table 1. 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 monitored continually 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 a 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 values 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. † Refer to the text in the Advisory for the full wording of the questionnaire items.

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

Table 2. Society for Neuroscience in Anesthesiology and Critical Care Member Survey: Percentage Responses*

Evidence Linkage/Intervention†	N	Agree	Equivocal	Disagree	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 monitored continually 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 a 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 values 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. † Refer to the text in the Advisory for the full wording of the questionnaire items.

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

Table 3. North American Neuro-Ophthalmology Society Member Survey: Percentage Responses*

Evidence Linkage/Intervention†	N	Agree	Equivocal	Disagree	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 monitored continually 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 a 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 values 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. † Refer to the text in the Advisory for the full wording of the questionnaire items.

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

Table 4. North American Spine Society Member Survey: Percentage Responses*

Evidence Linkage/Intervention†	N	Agree	Equivocal	Disagree	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 monitored continually 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 a 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 values 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. † Refer to the text in the Advisory for the full wording of the questionnaire items.

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

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