Practice Advisory for Perioperative Visual Loss Associated with Spine Surgery 2019

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

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This document updates the "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," adopted by the ASA in 2011 and published in 2012.[*1]

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Address correspondence to the American Society of Anesthesiologists: 1061 American Lane, Schaumburg, Illinois 60173. 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.

Methodology

Definition of Perioperative Visual loss

Perioperative visual loss (POVL) after spine surgery is a rare and disabling complication.[2-4] 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 from the immediate preoperative assessment through discharge from the acute healthcare facility. Conditions addressed in this Advisory include posterior ischemic optic neuropathy (PION), anterior ischemic optic neuropathy (AION), central and branch retinal artery occlusion (RAO), cerebral visual loss (CVL), and posterior reversible encephalopathy syndrome (PRES). AION damages the front of the optic nerve (the optic nerve head or optic disc), whereas PION injuries the portion of the optic nerve behind the eye.[5] "High-risk patients" are defined for this Advisory as those who undergo spine procedures while positioned prone and who have prolonged procedures, experience substantial blood loss, or both.[†]

Purpose of the Advisory

The purpose of this Advisory is to enhance awareness and reduce the frequency of POVL during and after spine surgery.

Focus of the Advisory

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. It does not include non-spine surgical procedures (*e.g.*, cardiac surgery, radical neck dissection). In addition, this Advisory does not apply to spine surgery patients younger than 12 years of age.

Application of the Advisory

This Advisory is intended for use by anesthesiologists, neurosurgeons, neuro-ophthalmologists, 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, operating room nurses and anesthesiology assistants. The Advisory also may serve as a resource for other physicians, nurses, and healthcare professionals who manage anesthetized patients.

[†] For the Advisory, prolonged procedures are defined as spine procedures greater than 4 hr. Substantial blood loss is defined as blood loss greater than 800 ml.

Task Force Members and Consultants

In 2017, the ASA Committee on Standards and Practice Parameters requested that this Advisory be updated. This Advisory update is a revision developed by an ASA-appointed task force of 16 members from various geographic areas of the United States, consisting of 6 anesthesiologists, 4 neuro-ophthalmologists, 4 neurosurgeons, and two methodologists. Eight physicians served as official liaisons from national organizations including the North American Neuro-Ophthalmology Society (NANOS), North American Spine Society (NASS), Society for Neuroscience in Anesthesiology and Critical Care (SNACC) and the American Association of Neurological Surgeons (AANS)/ Congress of Neurological Surgeons (CNS) Joint Section on Disorders of the Spine and Peripheral Nerves.

The task force developed this Advisory by means of a six-step process. First, criteria for evidence associated with POVL were established. Second, original peer-reviewed published research studies relevant to POVL were reviewed and evaluated. Third, a panel of expert consultants was asked to (a) participate in opinion surveys concerning the effectiveness and safety of various methods and interventions that might be used for prevention of POVL, and (b) review and comment on a draft of the Advisory developed by the task force. Fourth, survey opinions about the Advisory recommendations were solicited from a random sample of active ASA members and participating medical specialty societies. Fifth, the consultants were surveyed to assess their opinions on the feasibility of implementing the advisory. Sixth, all available information was used to build consensus within the task force to finalize the advisory. A summary of recommendations is in Appendix 1.

Availability and Strength of Evidence

Preparation of this updated advisory followed a rigorous methodological process. Evidence was obtained from two principal sources: scientific evidence and opinion-based evidence

Scientific Evidence

Scientific evidence used in the development of this advisory is based on cumulative findings from literature published in peer-reviewed journals. Literature citations are obtained from healthcare databases, direct internet searches, task force members, liaisons with other organizations, and manual searches of references located in reviewed articles.

Findings from the aggregated literature are reported in the text of this advisory by evidence category, level, and direction. Evidence categories refer specifically to the strength and quality of the research design of the studies. Category A evidence represents results obtained from randomized controlled trials (RCTs), and category B evidence represents observational results obtained from nonrandomized study designs or RCTs without pertinent comparison groups. When available, category A evidence is given precedence over category B evidence for any particular outcome. These evidence categories are divided further into evidence levels. Evidence levels refer specifically to the strength and quality of the summarized study findings (i.e., statistical findings, type of data, and number of studies reporting/replicating the findings). In

this document, only the highest level of evidence is included in the summary report for each intervention–outcome pair, including a directional designation of benefit, harm, or equivocality.

Category A. RCTs report comparative findings between clinical interventions for specified outcomes. Statistically significant ($P < 0.01$) outcomes are designated as either beneficial (B) or harmful (H) for the patient; statistically nonsignificant findings are designated as equivocal (E). ‡

Level 1: The literature contains a sufficient number of RCTs to conduct meta-analysis, and meta-analytic findings from these aggregated studies are reported as evidence.

Level 2: The literature contains multiple RCTs, but the number of RCTs is not sufficient to conduct a viable meta-analysis for the purpose of these Guidelines. Findings from these RCTs are reported separately as evidence.

Level 3: The literature contains a single RCT, and findings from this study are reported as evidence.

Category B. Observational studies or RCTs without pertinent comparison groups may permit inference of beneficial or harmful relationships among clinical interventions and clinical outcomes. Inferred findings are given a directional designation of beneficial (B), harmful (H), or equivocal (E). For studies that report statistical findings, the threshold for significance is $P < 0.01$.

Level 1: The literature contains nonrandomized comparisons (e.g., quasiexperimental, cohort [prospective or retrospective], or case-control research designs) with comparative statistics among clinical interventions for a specified clinical outcome.

Level 2: The literature contains noncomparative observational studies with associative statistics (e.g., relative risk, correlation, sensitivity, and specificity).

Level 3: The literature contains noncomparative observational studies with descriptive statistics (e.g., frequencies, percentages).

Level 4: The literature contains case reports.

Insufficient Literature. The lack of sufficient scientific evidence in the literature may occur when the evidence is either unavailable (i.e., no pertinent studies found) or inadequate. Inadequate literature cannot be used to assess relationships among clinical interventions and outcomes because a clear interpretation of findings is not obtained due to methodological concerns (e.g., confounding of study design or implementation) or the study does not meet the criteria for content as defined in the “Focus” of the advisory.

Opinion-based Evidence

All opinion-based evidence (e.g., survey data, open forum testimony (from original advisory), internet-based comments, letters, and editorials) relevant to each topic was considered in the development of these

‡ No relevant studies were found for this Advisory that met the criteria for “Category A” evidence.

guidelines. However, only the findings obtained from formal surveys are reported in the document. Opinion surveys were developed by the task force to address each clinical intervention identified in the document. Identical surveys were distributed to expert consultants and a random sample of members of the participating organizations.

Expert and Participating Membership Opinion Surveys. Survey findings from task force–appointed expert consultants, a random sample of the ASA membership, and membership samples from NANOS, SNACC and AANS/CNS are fully reported in this document. Survey responses were recorded using a 5-point scale and summarized based on median values.

Strongly Agree: Median score of 5 (at least 50% of the responses are 5)
Agree: Median score of 4 (at least 50% of the responses are 4 or 4 and 5)
Equivocal: Median score of 3 (at least 50% of the responses are 3, or no other response category or combination of similar categories contain at least 50% of the responses)
Disagree: Median score of 2 (at least 50% of responses are 2 or 1 and 2)
Strongly Disagree: Median score of 1 (at least 50% of responses are 1)

Informal Opinion. Open forum testimony obtained during development of the original advisory, internet-based comments, letters, and editorials are all informally evaluated and discussed during the formulation of guideline recommendations. When warranted, the task force may add educational information or cautionary notes based on this information.

Advisory Evidence and Recommendations

Preoperative Patient Evaluation and Preparation

Literature Findings. Comparative studies are insufficient to evaluate the impact of conducting an ophthalmic examination. Studies with observational findings indicate that certain conditions, including preoperative anemia, vascular risk factors (*e.g.*, hypertension, diabetes, peripheral vascular disease, coronary artery disease, previous stroke, carotid artery stenosis), obesity, and tobacco use, among other pre-operative characteristics (e.g., age, male sex, and diabetic retinopathy) may be associated with POVL (*Category B2-H evidence*). [§3,6-10] Two retrospective descriptive studies also indicate that POVL may occur in patients with the above conditions (*Category B3-H evidence*).[4,11] Case reports indicate that POVL may occur in patients whose medical history includes the above listed preoperative conditions (*Category B4-H evidence*[**]).[12-34] Although a small cup to disc ratio may render the axons of the optic nerve more susceptible to injury, the literature is insufficient to evaluate the role of optic nerve head anatomy as a risk factor for

[§] Refer to appendix 2 for details of the literature review and data analyses.
[**] Note that POVL may still occur in healthy patients without any of the above preoperative conditions.

perioperative AION or support routinely conducting a preoperative examination of the cup-to-disc in spine surgery patients.[5,35] One observational study reported that 86% of patients undergoing spine surgery in the prone position prefer to be informed of the risk of visual loss *(Category B3-B evidence)*.[36] The literature is insufficient to evaluate whether or not glaucoma is a risk factor for POVL.

Survey Findings. The consultants and members of ASA, AANS, NANOS and SNACC strongly agree with the recommendation to review a patient's preoperative history and perform an appropriate examination to identify patients with preoperative conditions such as preoperative anemia, vascular risk factors (*e.g.*, hypertension, diabetes, peripheral vascular disease, coronary artery disease, previous stroke, carotid artery stenosis), obesity, and tobacco use. Consultants and members of the participating organizations agree with the recommendation to inform patients that certain preoperative conditions may increase their risk of POVL in spine surgery. The consultants, members of ASA and NANOS strongly agree, and members of AANS and SNACC agree with the recommendation to inform patients in whom prolonged procedures, substantial blood loss, or both are anticipated that there may be an increased risk of POVL. Finally, consultants and members of ASA, AANS and SNACC agree with the recommendation to determine on a case-by-case basis whether or not to inform patients who are *not* anticipated to be "high-risk" for visual loss; members of NANOS were equivocal.

Advisory Recommendations for Preoperative Patient Evaluation and Preparation

- Review a patient's preoperative history and perform an appropriate examination to identify patients with conditions such as preoperative anemia, vascular risk factors (*e.g.*, hypertension, diabetes, peripheral vascular disease, coronary artery disease, previous stroke, carotid artery stenosis), obesity, and tobacco use.
- Inform patients that certain preoperative conditions may increase their risk of POVL in spine surgery. These include, but are not limited to those who are male, obese, have vascular disease risk factors such as hypertension and peripheral vascular disease, or have diabetic retinopathy.
- Inform patients in whom prolonged procedures, substantial blood loss, or both are anticipated that there may be an increased risk of POVL.††
    - Determine on a case-by-case basis whether or not to inform patients who are *not* anticipated to be "high-risk" for visual loss.

Intraoperative Management

Intraoperative management topics consist of (1) blood pressure management, (2) management of blood loss and administration of fluids, (3) use of vasopressors, (4) patient and head positioning, and (5) staging of surgical procedures.

†† 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

Blood Pressure Management

Literature Findings. Two retrospective observational studies reported equivocal findings regarding the association of hypotension and perioperative ION *(Category B2-E evidence)*.[10,11] Case reports indicate visual loss occurring after procedures in which hypotensive episodes occurred intraoperatively (*Category B4-H evidence*).[20,21,25,27,34,37-40]

Although case reports describe POVL occurring after procedures in which intraoperative hypotension was deliberately maintained (*i.e.* deliberate hypotension) for patients without hypertension[18,24,29,41-49] or for patients with well-controlled chronic hypertension[18,26,28,29,50,51] (*Category B4-E evidence*), the literature is equivocal on whether or not the risk of ION is increased due to intraoperative hypotension, either deliberately induced or due to use of pre-operative anti-hypertensive drugs or intra-operative anesthetics *(Category B4-E evidence)*.‡‡

Survey Findings. The consultants and members of ASA, AANS, NANOS and SNACC strongly agree with the recommendation to continually monitor systemic blood pressure in high-risk patients. The consultants and members of ASA, and SNACC strongly agree and members of AANS and NANOS agree with the recommendation to and to assess the patient's baseline blood pressure on a case-by-case basis. Consultants and members of the participating organizations agree with the recommendation to determine on a case-by case basis if deliberate hypotension should be used in high-risk patients. The consultants and members of ASA, NANOS and SNACC strongly agree and members of AANS agree with the recommendation to check for the presence of pre-operative hypertension, its degree of control, the pre-operative use of anti-hypertensive drugs, and the patient's risk of end-organ damage before using deliberate hypotension in a high-risk patient.

Consultants and members of ASA, AANS, and SNACC strongly agree and members of NANOS agree with the recommendation to discuss with the surgeon if deliberate hypotension is necessary. Consultants and members of ASA and SNACC strongly agree and members of AANS and NANOS agree with the recommendation to maintain arterial pressure at higher levels in hypertensive patients to prevent risks to end organs. The consultants and members of the participating organizations agree with the recommendation to use deliberate hypotension in high-risk patients only when the anesthesiologist and surgeon agree that its use is essential, and strongly agree with the recommendation to treat prolonged significant decreases in blood pressure.

Management of Blood Loss and Administration of Fluids

Literature Findings. Two observational studies report that blood loss and duration of surgery are associated with POVL (*Category B2-H evidence*).[8,52] Three descriptive observational studies indicate POVL may occur with substantial blood loss, prolonged procedures, or both (*Category B3-H evidence*).[4,11,53] Case

‡‡ Because deliberate hypotension can only decrease arterial, and not venous bleeding, it may be of relatively limited utility in patients undergoing spine fusion.

reports also describe POVL occurring after prolonged procedures[12,13,37,43,54-61], substantial intraoperative blood loss,[20,21,26,33,41,42,49,62-65] or both[14-18,23,25,27-29,33,39,40,44,45,47,51,66-71] (*Category B4-H evidence*).[§§] One case report described POVLs occurring in a spine surgery patient even though the patient's hematocrit was monitored every 1.5 hours throughout the procedure (*Category B4-E evidence*).[13]

Although comparative studies are insufficient to evaluate the impact on visual loss of the relative percentages of intraoperatively administered crystalloids and colloids on the occurrence of POVL, one case-control study reported the percent of crystalloid in the total volume replacement had no statistically significant effect on developing ION whereas higher colloid as percent of total nonblood replacement was associated with a reduced risk of developing ION (*Category B2-E evidence*).[8] Case reports indicate that visual loss still may regardless of the type and relative percentages of fluids used (*Category B4-E evidence*).[15,17,23,25,27,29,30,34,37,39,42,44,45,47,51,64-70]

Survey Findings. The consultants and members of ASA, AANS and SNACC strongly agree and members of NANOS agree with the recommendation to periodically monitor hemoglobin or hematocrit values during surgery in high-risk patients who experience substantial blood loss. Consultants and members of the participating organizations strongly agree with the recommendation to use transfusions of blood as deemed appropriate. Consultants and members ASA, AANS and SNACC agree with the recommendation that crystalloids or colloids alone, or in combination may be used to maintain adequate replacement or intravascular volume; members of NANOS are equivocal.

Use of Vasopressors

Literature Findings. Comparative studies are insufficient to evaluate the relationship of the perioperative administration of high-dose -adrenergic agonists during spine surgery to POVL. One retrospective observational study reported equivocal findings for perioperative vasopressors use when patients with POVL compared with patients without POVL (*Category B2-E evidence*).[8] One case report indicated that POVL still may occur in spine surgery patients in whom extensive intraoperative hypotension was treated with multiple doses of phenylephrine and ephedrine (*Category B4-E evidence*).[34]

Survey Findings. Consultants and members of ASA and SNACC strongly agree and members of AANS and NANOS agree with the recommendation that adrenergic agonists may be used on a case-by-case basis when it is necessary to correct for hypotension.

Patient and Head Positioning Devices

Literature Findings. One retrospective study comparing POVL patients with patients without POVL reported a significant association between the use of the Wilson frame and ION *(Category B2-H evidence)*.[8] Retrospective observational studies obtained from institutional databases[***] also describe POVL occurring

[§§] For this Advisory, prolonged procedures are defined as spine procedures greater than 4 hr. Substantial blood loss is defined as blood loss greater than 800 ml.

[***] ASA POVL Registry and The Scoliosis Research Society database

when a patient is positioned prone on Wilson frame, positioned prone on a Jackson frame, or when the patient's head is supported by various devices such as Mayfield head holder, horseshoe, headrest, tongs, halo, or pillow (*Category B3-H evidence)*.[4,11] ††† Case reports indicate that patient positioning resulting in direct pressure to the eyes (*e.g.*, from the use of a headrest, sheet roll, or other device) may precede the onset of POVL from RAO in spine surgery patients (*Category B4-H evidence*).[12,21,30,48,49,56,57,60,68,72-75] Comparative studies are insufficient to evaluate if positioning the patient's head below the heart compared with positioning the head in neutral or higher is associated with POVL.

Monitoring the eyes during spine surgery may assist in the early identification of eye compression. Although there are a number of head positioning devices that enable the eyes to be checked for compression when the patient is positioned prone, the literature is insufficient to support superiority of any one head positioning device, or to recommend a particular frequency of eye checks.

Survey Findings. The consultants and members of SNACC strongly agree and members of ASA, AANS and NANOS agree with the recommendation to position the high-risk patient so that the head is level with or higher than the rest of the body when possible. Consultants and members of ASA and SNACC strongly agree and members of AANS and NANOS agree with the recommendation to maintain the high-risk patient's head in a neutral forward position (*e.g.*, without significant neck flexion, extension, lateral flexion, or rotation) when possible. Consultants and members of the participating organizations strongly agree with the recommendation to avoid direct pressure on the eye to prevent RAO. Consultants and members of AANS and SNACC strongly agree and members of ASA and NANOS agree with the recommendation that a head holder may be applied by the spine surgeon in patients in whom head positioning is challenging. Finally, consultants and members of the participating organizations strongly agree with the recommendation to check the position of the eyes periodically during surgery to ensure the head has not moved and there is no eye compression.

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. Staging of spine surgical procedures involves performing the operative procedure in two or more operations, as opposed to a single surgical procedure.[76-79]

Literature Findings. The literature is insufficient to examine the impact of surgical staging on reducing the frequency of POVL in spine surgery patients.

Survey Findings. The consultants and members of ASA, AANS and SNACC strongly agree and members of NANOS agree with the recommendation that staged spine procedures may be used on a case-by-case basis for high-risk patients.

††† 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.

Advisory Recommendations for Intraoperative Management

Blood Pressure Management.

- Continually[‡‡‡] monitor systemic blood pressure in high-risk patients.
  - Assess the patient's baseline blood pressure on a case-by-case basis.
- Determine on a case-by case basis if deliberate hypotension should be used in high-risk patients.
  - Check for the presence of pre-operative hypertension, its degree of control, the pre-operative use of anti-hypertensive drugs, and the patient's risk of end-organ damage before using deliberate hypotension in a high-risk patient.
    - Discuss with the surgeon if deliberate hypotension is necessary.
  - Maintain arterial pressure at higher levels in hypertensive patients to prevent risks to end organs.
  - Use deliberate hypotension in high-risk patients only when the anesthesiologist and surgeon agree that its use is essential.
    - Treat prolonged significant decreases in blood pressure.

Management of Blood Loss and Administration of Fluids.

- Periodically monitor hemoglobin or hematocrit values during surgery in high-risk patients who experience substantial blood loss.[§§§]
  - Use transfusions of blood as deemed appropriate.
  - Crystalloids or colloids alone or in combination may be used to maintain adequate replacement or intravascular volume.

Use of Vasopressors.

- Adrenergic agonists may be used on a case-by-case basis when it is necessary to correct for hypotension.

Patient and Head Positioning Devices.

- Position the high-risk patient so that the head is level with or higher than the rest of the body when possible.
  - Maintain the high-risk patient's head in a neutral forward position (*e.g.*, without significant neck flexion, extension, lateral flexion, or rotation) when possible.
- Avoid direct pressure on the eye to prevent RAO.

‡‡‡ Note that "continual" is defined as "repeated regularly and frequently in steady and rapid succession" whereas "continuous" means prolonged without any interruption at any time (from ASA Standards for Basic Anesthetic Monitoring)

§§§ 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.

- A head holder may be applied by the spine surgeon in patients in whom head positioning is challenging.
- Check the position of the eyes periodically during surgery to ensure the head has not moved and there is no eye compression.

Staging of Surgical Procedures.

- Staged spine procedures may be used on a case-by-case basis for high-risk patients.

Postoperative Management

Literature Findings. The literature is insufficient to evaluate the effect of assessing a high-risk patient's vision when the patient becomes alert. The literature is insufficient to evaluate the use of magnetic resonance imaging (MRI) or computerized tomography (CT) to rule out intracranial causes of visual loss or the capacity of orbital MRI or CT to detect optic nerve changes in POVL.

A case report of one spine surgery patient with bilateral PION indicated that visual recovery occurred after the deliberate maintenance of increased hematocrit and blood pressure (*Category B4-B evidence*).[31] Two case reports indicated that the patients' visual loss improved with the administration of corticosteroids to treat ION (*Category C4-B evidence*)[59,66]: Fourteen case reports found no visual improvement following the administration of steroids (*Category B4-E evidence*).[22,29,33,34,40,41,43,57,64,71-73,75] There is insufficient evidence to support the administration of antiplatelet agents or intraocular pressure-lowering agents in the treatment of ION. With respect to perioperative RAO, the literature is insufficient to support the use of any form of treatment.[****] At this time, there is no evidence of a role for antiplatelet agents, corticosteroids, or intraocular pressure-lowering agents in the management of perioperative ION.

Survey Findings. The consultants and members of ASA, AANS, NANOS and SNACC agree that for the high-risk patient, conduct an ophthalmological assessment when the patient becomes alert (*e.g.*, in the recovery room, intensive care unit, or nursing floor). Consultants and members of the participating organizations strongly agree with the recommendation that if there is concern regarding potential visual loss, to obtain an urgent ophthalmologic consultation to determine its cause. Consultants strongly agree and members of the participating organizations agree with the recommendation that CT or MRI may be used on a case-by-case basis to rule out intracranial causes of visual loss as well as to visualize an abnormal (*e.g.,* enhancing) optic nerve. Finally, consultants and members of the participating organizations strongly agree with the recommendation that additional management may include optimizing hemoglobin or hematocrit values, hemodynamic status, and arterial oxygenation.

[****] The pathogenesis of RAO in this setting is different from patients with spontaneous RAO. Although thrombolysis via catheter in the central retinal artery may dissolve a clot within the early hours after non-perioperative RAO, bleeding in a newly post-operative patient is a potential risk.

Advisory Recommendations for Postoperative Management

- For the high-risk patient, conduct an ophthalmological assessment 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, obtain an urgent ophthalmologic consultation to determine its cause.
  - CT or MRI may be used on a case-by-case basis to rule out intracranial causes of visual loss as well as to visualize an abnormal (*e.g.,* enhancing) optic nerve.
  - Additional management may include optimizing hemoglobin or hematocrit values, hemodynamic status, and arterial oxygenation.

Appendix 1: Summary of Advisory Statements

Preoperative Patient Evaluation and Preparation

- Review a patient's preoperative history and perform an appropriate examination to identify patients with conditions such as preoperative anemia, vascular risk factors (*e.g.*, hypertension, diabetes, peripheral vascular disease, coronary artery disease, previous stroke, carotid artery stenosis), obesity, and tobacco use.
  - Inform patients that certain preoperative conditions may increase their risk of POVL in spine surgery. These include, but are not limited to those who are male, obese, have vascular disease risk factors such as hypertension and peripheral vascular disease, or have diabetic retinopathy.
  - Inform patients in whom prolonged procedures, substantial blood loss, or both are anticipated that there may be an increased risk of POVL.††††
    - Determine on a case-by-case basis whether or not to inform patients who are *not* anticipated to be "high-risk" for visual loss.

Intraoperative Management

Blood Pressure Management.

- Continually‡‡‡‡ monitor systemic blood pressure in high-risk patients.
  - Assess the patient's baseline blood pressure on a case-by-case basis.
- Determine on a case by case basis if deliberate hypotension should be used in high-risk patients.
  - Check for the presence of pre-operative hypertension, its degree of control, the pre-operative use of anti-hypertensive drugs, and the patient's risk of end-organ damage before using deliberate hypotension in a high-risk patient.
    - Discuss with the surgeon if deliberate hypotension is necessary.
  - Maintain arterial pressure at higher levels in hypertensive patients to prevent risks to end organs.
  - Use deliberate hypotension in high-risk patients only when the anesthesiologist and surgeon agree that its use is essential.
    - Treat prolonged significant decreases in blood pressure.

†††† 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

‡‡‡‡ Note that "continual" is defined as "repeated regularly and frequently in steady and rapid succession" whereas "continuous" means prolonged without any interruption at any time (from ASA Standards for Basic Anesthetic Monitoring)

Management of Blood Loss and Administration of Fluids.

- Periodically monitor hemoglobin or hematocrit values during surgery in high-risk patients who experience substantial blood loss.[§§§§]
  - Use transfusions of blood as deemed appropriate.
  - Crystalloids or colloids alone or in combination may be used to maintain adequate replacement or intravascular volume.

Use of Vasopressors.

- Adrenergic agonists may be used on a case-by-case basis when it is necessary to correct for hypotension.

Patient and Head Positioning Devices.

- Position the high-risk patient so that the head is level with or higher than the rest of the body when possible.
  - Maintain the high-risk patient's head in a neutral forward position (*e.g.*, without significant neck flexion, extension, lateral flexion, or rotation) when possible.
- Avoid direct pressure on the eye to prevent RAO.
  - A head holder may be applied by the spine surgeon in patients in whom head positioning is challenging.
- Check the position of the eyes periodically during surgery to ensure the head has not moved and there is no eye compression.

Staging of Surgical Procedures.

- Staged spine procedures may be used on a case-by-case basis for high-risk patients.

Postoperative Management

- For the high-risk patient, conduct an ophthalmological assessment 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, obtain an urgent ophthalmologic consultation to determine its cause.
  - CT or MRI may be used on a case-by-case basis to rule out intracranial causes of visual loss as well as to visualize an abnormal (*e.g.,* enhancing) optic nerve.
  - Additional management may include optimizing hemoglobin or hematocrit values, hemodynamic status, and arterial oxygenation.

Appendix 2: Methods and Analyses

For this updated practice advisory, a systematic search and review of peer reviewed published literature was conducted, with scientific findings summarized and reported below and in the document. Assessment of conceptual issues, and the practicality and feasibility of the advisory recommendations was also evaluated, with opinion data collected from surveys and other sources. Both the systematic literature review and the opinion data are based on evidence linkages, or statements regarding potential relationships between interventions and outcomes associated with POVL associated with a spine procedure during which general anesthesia is administered and permanent impairment or total loss of sight occurs. The evidence

[§§§§] 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.

linkage interventions are listed below.[*****] The evidence model below guided the search, providing inclusion and exclusion information regarding patients, procedures, practice settings, providers, clinical interventions, and outcomes. The ASA Committee on Standards and Practice Parameters reviews all practice guidelines at the ASA annual meeting and determines update and revision timelines. The policy of the ASA Committee on Standards and Practice Parameters is to update practice guidelines every 5 yr.

Evidence Model

Patients

- Inclusion criteria:
  - Patients undergoing back or spine surgery
  - Patients positioned prone
  - Patients receiving general anesthesia
- Exclusion criteria:
  - Children younger than 12 years
  - Patients not positioned prone

Procedures

- Inclusion criteria:
  - Back surgery
  - Spine surgery
- Exclusion criteria:
  - Procedures where anesthetic care is not provided
  - Non-supine surgical procedures
    - Cardiac surgery
    - Radical neck dissection
    - Ocular surgery
    - Intracranial procedures

Practice Settings

- Inclusion criteria:
  - Any health care facility
    - Medical centers
    - Hospitals
    - Operating room
    - Spine surgery postop nursing unit
    - Other anesthetizing locations
    - Recovery rooms (PACU)
    - Intensive care units (ICU)
    - Outpatient procedural units
    - Office-based practices

- Exclusion criteria:
  - Non-perioperative settings

Providers

- Inclusion criteria:
  - All anesthesia providers
    - Anesthesiologists
    - Providers working under the direction of anesthesiologists
    - Orthopedic surgeons

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

- Neuro-ophthalmologists
- Neurologists
- Nurse anesthetists
- Perioperative nurses

- Exclusion criteria:
  - Individuals who do not evaluate or care for patients undergoing surgery, nor consult on them

Interventions

- Preoperative Evaluation.
  - Ophthalmic or neuro-ophthalmic evaluation for high-risk patients or procedures†††††
  - Informing patients of the risk of POVL in spine surgery
  - Determine acceptable blood pressure according to patient's preoperative history (i.e., hypertensive patients at risk)

- Preoperative Preparation.
  - Pharmacologic methods to reduce increased intraocular pressure (i.e., use of topical beta blockers)
  - Alpha 2 agonists to protect the optic nerve (e.g., dexmedetomidine)
  - Mild deliberate hypothermia to protect the optic nerve (by maintaining temperature 34 C)

- Intraoperative Management.
  - Blood pressure.
    - Continual‡‡‡‡‡ monitoring of blood pressure to avoid hypotension§§§§§
  - Blood Loss and Administration of Fluids.
    - Continual monitoring of hydration levels to avoid over hydration
    - Fluid replacement limitation
    - Colloids (e.g., albumin, hetastarch) *versus* crystalloids (e.g., saline, lactated ringer's) to maintain optimal levels of hydration
    - Periodic monitoring of hemoglobin/hematocrit values during surgery in high-risk patients who experience substantial blood loss.
  - Patient Positioning.
    - Avoidance of direct pressure on the globe of the eye
    - Positioning the patient so that the head is level with or higher than the heart
    - Maintaining of face in a neutral forward position (e.g., without significant neck flexion or extension, lateral flexion, or rotation)
  - Surgical procedures.
    - Use of staged procedures for spine surgery when anticipated length is greater than 6 hours

††††† For this Advisory, prolonged procedures are defined as spine procedures greater than 4 hr. Substantial blood loss is defined as blood loss greater than 800 ml.

‡‡‡‡‡ Note that "continual" is defined as "repeated regularly and frequently in steady and rapid succession" whereas "continuous" means prolonged without any interruption at any time (from ASA Standards for Basic Anesthetic Monitoring)

§§§§§ Hypotension is defined as mean pressures < 20% below baseline, or systolic BP < 90 mm Hg despite surgical incision

- Postoperative Management.
  - Assess patient's visual status for loss of vision
  - Assess visual evoked potentials to detect optic nerve dysfunction
  - Begin initial treatment (e.g., increase blood pressure and hemoglobin/hematocrit if appropriate, administer supplemental oxygen, antiplatelet drugs, aspirin, or steroids)

Outcomes

- Inclusion criteria:
  - Perioperative visual loss (POVL)
    - Posterior ischemic optic neuropathy (PION)
    - Anterior ischemic optic neuropathy (AION)
    - Central and branch retinal artery occlusion (RAO)
    - Posterior reversible encephalopathy syndrome (PRES)
    - Cerebral visual loss (CVL)

- Exclusion criteria:
  - Non-perioperative visual loss
  - Acute angle-closure glaucoma
  - Retinal detachment
  - Vitreous hemorrhage

Guideline goals

- To reduce the frequency of POVL
- To enhance awareness of the potential for POVL
- To benefit patients by reducing the risk of visual loss.
- To help guide those caring for these patients in preventing and identifying the problem

Evidence collection

- Literature inclusion criteria:
  - Randomized controlled trials
  - Prospective nonrandomized comparative studies (e.g., quasi-experimental, cohort)
  - Retrospective comparative studies (e.g., case-control)
  - Observational studies (e.g., correlational or descriptive statistics)
  - Case reports, case series
- Literature exclusion criteria (except to obtain new citations):
  - Editorials
  - Literature reviews
  - Meta-analyses
  - Abstracts greater than 5 years old
  - Unpublished studies
  - Studies in non-peer reviewed journals
  - Newspaper articles
- Survey evidence:
  - Expert consultant survey
  - ASA membership survey
  - Other participating organization surveys
  - Reliability survey
  - Feasibility survey

State of the Literature. For the systematic review, potentially relevant clinical studies were identified *via* electronic and manual searches. Healthcare database searches included PubMed, EMBASE, Web of Science, Google Books, and the Cochrane Central Register of Controlled Trials. The searches covered a

6.5-yr period from January 1, 2012, through June 1, 2018. Accepted studies from the previous advisory were also re-reviewed, covering the period of January 1, 2002, through December 31, 2011. Only studies containing original findings from peer-reviewed journals were acceptable. Editorials, letters, and other articles without data were excluded. A literature search strategy and PRISMA[******] flow diagram is available as Supplemental Digital Content 2, http://links.lww.com/ALN/XXXXXX.

In total, 569 new citations were identified, with 484 articles assessed for eligibility. After review, 452 were excluded, with 32 new studies meeting the above stated criteria. These studies were combined with 48 pre-2012 articles used in the previous advisory and 5 provided by task force members, resulting in a total of 85 articles accepted as evidence for these guidelines. In this document, 79 are referenced, with a complete bibliography of articles used to develop these guidelines, organized by section, available as Supplemental Digital Content 3, http://links.lww.com/ALN/XXXXXXXX.

Each pertinent outcome reported in a study was classified by evidence category and level and designated as beneficial, harmful, or equivocal. Findings were then summarized for each evidence linkage and reported in the text of the updated Advisory, with evidence tables available as Supplemental Digital Content 4, http://links.lww.com/ALN/XXXXXX.

Interobserver agreement among task force members and two methodologists was obtained by interrater reliability testing of 33 randomly selected studies. Agreement levels using a κ statistic for two-rater agreement pairs were as follows: (1) research design, κ = 0.64 to 0.94; (2) type of analysis, κ = 0.62 to 1.00; (3) evidence linkage assignment, κ = 0.66 to 0.81; and (4) literature inclusion for database, κ = 0.27 to 1.00. Three-rater κ values were: (1) research design, κ = 0.76; (2) type of analysis, κ = 0.74; (3) linkage assignment, κ = 0.74; and (4) literature database inclusion, κ = 0.33. These values represent moderate to high levels of agreement.

Consensus-based Evidence

Consensus was obtained from multiple sources, including: (1) survey opinion from consultants[††††††] who were selected based on their knowledge or expertise in moderate procedural sedation and analgesia; (2) survey opinions from a randomly selected sample of active members of the ASA, AANS, NANOS, and SNACC; (3) testimony from attendees of publicly held open forums for the original advisory at a national anesthesia meeting[‡‡‡‡‡‡]; (4) internet commentary; and (5) task force opinion and interpretation. The survey rate of return was 50% (n = 35 of 70) for consultants. For membership respondents, survey data were collected from 259 ASA members, 103 AANS members, 119 NANOS members, and 57 SNACC members. The results of the surveys are reported in tables 1–4 and are summarized in the text of the advisory.

For the Feasibility survey, consultants were asked to indicate which, if any, of the evidence linkages would change their clinical practices if the guidelines were instituted. The rate of return was ___% (n = __ of

[******] Preferred reporting items of systematic reviews and meta-analyses

[††††††] Consultants were drawn from the following specialties where perioperative visual loss is a concern: anesthesiology, ophthalmology, orthopedic surgery, and neurosurgery.

[‡‡‡‡‡‡] Society for Ambulatory Anesthesia 14th Annual Meeting, Seattle, Washington, April 30, 1999.

___). The percent of responding consultants expecting *no change* associated with each linkage were as follows (__%): preoperative evaluation – ___%; preoperative preparation – ___%; blood pressure monitoring – ___%; fluid management – ___%; management of blood loss – ; patient positioning – ___%; surgical procedures – ___%; and postoperative management – ___%. ___ respondents (___%) indicated that the guidelines would have *no effect* on the amount of time spent on a typical case with the implementation of these guidelines. ___ respondents (___%) indicated that there would be an increase in the amount of time, with ___ of these respondents estimating an increase ranging from __ to __ min. ___ respondents (___%) estimated a decrease in the amount of time they would spend on a typical case.

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Competing Interests

The authors declare no competing interests. Drs. Roth, Newman and Todd have provided expert witness evaluation and testimony in cases of POVL on behalf of patients, physicians, and hospitals.

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Address correspondence to the American Society of Anesthesiologists: 1061 American Lane, Schaumburg, Illinois 60173. These updated Practice Guidelines, and all ASA Practice Parameters, may be obtained at no cost through the journal Web site, www.anesthesiology.org.

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Table 1. Expert Consultant Survey Results (Response Rate = 51%)

Recommendations	Answer Rate N (%)	Strongly Agree (%)	Agree (%)	Equivocal (%)	Disagree (%)	Strongly Disagree (%)
Preoperative patient evaluation and preparation						
Review a patient's preoperative history and perform an appropriate examination to identify patients with conditions such as preoperative anemia, vascular risk factors (e.g., hypertension, diabetes, peripheral vascular disease, coronary artery disease, previous stroke, carotid artery stenosis), obesity, and tobacco use.	35 (97)	83*	14	3	0	0
Inform patients that certain preoperative conditions may increase their risk of POVL in spine surgery. These include, but are not limited to those who are male, obese, have vascular disease risk factors such as hypertension and peripheral vascular disease, or have diabetic retinopathy.	35 (97)	40	46*	11	0	0
Inform patients in whom prolonged procedures, substantial blood loss, or both are anticipated that there may be an increased risk of POVL.	35 (97)	69*	20	11	0	0
Determine on a case-by-case basis whether or not to inform patients who are not anticipated to be "high-risk" for visual loss.	35 (97)	31	31*	17	20	0
Intraoperative blood pressure management						
Continually monitor systemic blood pressure in high-risk patients.	34 (94)	82*	9	9	0	0
Assess the patient's baseline blood pressure on a case-by-case basis.	33 (92)	67*	33	0	0	0
Determine on a case-by case basis whether deliberate hypotension should be used in high-risk patients.	34 (94)	44	15*	3	3	35
Check for the presence of pre-operative hypertension, its degree of control, the pre-operative use of anti-hypertensive drugs, and the patient's risk of end-organ damage before using deliberate hypotension in a high-risk patient.	34 (94)	71*	12	9	3	6
Discuss with the surgeon whether deliberate hypotension is necessary.	34 (94)	68*	15	3	6	9
Maintain arterial pressure at higher levels in hypertensive patients to prevent risks to end organs.	33 (92)	64*	21	15	0	0
Use deliberate hypotension in high-risk patients only when the anesthesiologist and surgeon agree that its use is essential despite employing other means to minimize bleeding.	35 (97)	37	34*	6	6	17
Treat prolonged significant decreases in blood pressure.	34 (94)	91*	9	0	0	0
Adrenergic agonists may be used on a case-by-case basis when it is necessary to correct for hypotension.	33 (92)	58*	39	3	0	0
Intraoperative patient and head position devices and surgical staging						
Periodically monitor hemoglobin or hematocrit values during surgery in high-risk patients who experience substantial blood loss.	35 (97)	89*	9	3	0	0
Use transfusions of blood as deemed appropriate.	35 (97)	83*	17	0	0	0
Crystalloids or colloids alone or in combination may be used to maintain adequate replacement or intravascular volume.	35 (97)	29	*34	23	9	6
Position the high-risk patient so that the head is level with or higher than the heart when possible.	35 (97)	49*	34	9	9	0

Maintain the high-risk patient's head in a neutral forward position (e.g., without significant neck flexion, extension, lateral flexion, or rotation) when possible.	33 (92)	67*	30	3	0	0
Avoid direct pressure on the eye to prevent retinal artery occlusion (RAO).	34 (94)	88*	12	0	0	0
A head holder may be applied by the spine surgeon in patients in whom head positioning is challenging.	35 (97)	63*	31	6	0	0
Check the position of the eyes periodically during surgery to ensure the head has not moved and there is no eye compression.	35 (97)	91*	9	0	0	0
Staged spine procedures may be used on a case-by-case basis for high-risk patients.	34 (94)	65*	32	3	0	0
Postoperative management						
For the high-risk patient, conduct an ophthalmological assessment when the patient becomes alert (e.g., in the recovery room, intensive care unit, or nursing floor).	35 (97)	34	17*	29	20	0
If there is concern regarding potential visual loss, obtain an urgent ophthalmologic consultation to determine its cause.	34 (94)	82*	18	0	0	0
CT or MRI may be used on a case-by-case basis to rule out intracranial causes of visual loss as well as to visualize an abnormal (e.g., enhancing) optic nerve.	34 (94)	50*	32	18	0	0
Additional management may include optimizing hemoglobin or hematocrit values, hemodynamic status, and arterial oxygenation.	35 (97)	63*	29	9	0	0

***Median**

Table 2. ASA Member Survey Results (Response Rate = 5%)

Recommendations	Answer Rate N (%)	Strongly Agree (%)	Agree (%)	Equivocal (%)	Disagree (%)	Strongly Disagree (%)
Preoperative patient evaluation and preparation						
Review a patient's preoperative history and perform an appropriate examination to identify patients with conditions such as preoperative anemia, vascular risk factors (e.g., hypertension, diabetes, peripheral vascular disease, coronary artery disease, previous stroke, carotid artery stenosis), obesity, and tobacco use.	258 (99)	73*	24	3	0	0
Inform patients that certain preoperative conditions may increase their risk of POVL in spine surgery. These include, but are not limited to those who are male, obese, have vascular disease risk factors such as hypertension and peripheral vascular disease, or have diabetic retinopathy.	259 (100)	42	39*	15	3	1
Inform patients in whom prolonged procedures, substantial blood loss, or both are anticipated that there may be an increased risk of POVL.	257 (99)	52*	35	11	2	1
Determine on a case-by-case basis whether or not to inform patients who are not anticipated to be "high-risk" for visual loss.	256 (98)	18	43*	19	14	5
Intraoperative blood pressure management						
Continually monitor systemic blood pressure in high-risk patients.	236 (91)	67*	23	8	1	0
Assess the patient's baseline blood pressure on a case-by-case basis.	234 (90)	53*	29	3	11	4

Determine on a case-by case basis whether deliberate hypotension should be used in high-risk patients.	236 (91)	44	26*	7	14	9
Check for the presence of pre-operative hypertension, its degree of control, the pre-operative use of anti-hypertensive drugs, and the patient's risk of end-organ damage before using deliberate hypotension in a high-risk patient.	235 (90)	73*	23	1	2	1
Discuss with the surgeon whether deliberate hypotension is necessary.	236 (91)	73*	24	1	0	2
Maintain arterial pressure at higher levels in hypertensive patients to prevent risks to end organs.	237 (91)	60*	31	7	2	0
Use deliberate hypotension in high-risk patients only when the anesthesiologist and surgeon agree that its use is essential despite employing other means to minimize bleeding.	235 (90)	49	29*	8	7	7
Treat prolonged significant decreases in blood pressure.	236 (91)	86*	14	0	0	0
Adrenergic agonists may be used on a case-by-case basis when it is necessary to correct for hypotension.	233 (90)	60*	36	2	2	0
Intraoperative patient and head position devices and surgical staging						
Periodically monitor hemoglobin or hematocrit values during surgery in high-risk patients who experience substantial blood loss.	228 (88)	73*	23	4	0	0
Use transfusions of blood as deemed appropriate.	226 (87)	71*	28	1	0	0
Crystalloids or colloids alone or in combination may be used to maintain adequate replacement or intravascular volume.	226 (87)	31	43*	19	6	1
Position the high-risk patient so that the head is level with or higher than the heart when possible.	222 (85)	32	43*	21	2	1
Maintain the high-risk patient's head in a neutral forward position (e.g., without significant neck flexion, extension, lateral flexion, or rotation) when possible.	220 (85)	62*	33	4	0	0
Avoid direct pressure on the eye to prevent retinal artery occlusion (RAO).	219 (84)	84*	16	0	0	0
A head holder may be applied by the spine surgeon in patients in whom head positioning is challenging.	222 (85)	43	50*	6	0	0
Check the position of the eyes periodically during surgery to ensure the head has not moved and there is no eye compression.	221 (85)	78*	20	1	0	0
Staged spine procedures may be used on a case-by-case basis for high-risk patients.	219 (84)	58*	33	8	0	0
Postoperative management						
For the high-risk patient, conduct an ophthalmological assessment when the patient becomes alert (e.g., in the recovery room, intensive care unit, or nursing floor).	218 (84)	22	39*	28	9	2
If there is concern regarding potential visual loss, obtain an urgent ophthalmologic consultation to determine its cause.	219 (84)	68*	29	2	0	0
CT or MRI may be used on a case-by-case basis to rule out intracranial causes of visual loss as well as to visualize an abnormal (e.g., enhancing) optic nerve.	217 (83)	34	48*	17	1	0
Additional management may include optimizing hemoglobin or hematocrit values, hemodynamic status, and arterial oxygenation.	217 (83)	61*	37	2	0	0

*Median

Table 3. AANS Member Survey Results (Response Rate = %)

Recommendations	Answer Rate N (%)	Strongly Agree (%)	Agree (%)	Equivocal (%)	Disagree (%)	Strongly Disagree (%)
Preoperative patient evaluation and preparation						
Review a patient's preoperative history and perform an appropriate examination to identify patients with conditions such as preoperative anemia, vascular risk factors (e.g., hypertension, diabetes, peripheral vascular disease, coronary artery disease, previous stroke, carotid artery stenosis), obesity, and tobacco use.	103 (99)	53*	34	11	1	1
Inform patients that certain preoperative conditions may increase their risk of POVL in spine surgery. These include, but are not limited to those who are male, obese, have vascular disease risk factors such as hypertension and peripheral vascular disease, or have diabetic retinopathy.	103 (99)	29	37*	27	7	0
Inform patients in whom prolonged procedures, substantial blood loss, or both are anticipated that there may be an increased risk of POVL.	103 (99)	35	41*	16	9	0
Determine on a case-by-case basis whether or not to inform patients who are not anticipated to be "high-risk" for visual loss.	101 (97)	18	40*	17	17	9
Intraoperative blood pressure management						
Continually monitor systemic blood pressure in high-risk patients.	89 (85)	69*	28	2	0	1
Assess the patient's baseline blood pressure on a case-by-case basis.	87 (84)	33	46*	9	7	5
Determine on a case-by case basis whether deliberate hypotension should be used in high-risk patients.	88 (85)	24	27*	18	18	13
Check for the presence of pre-operative hypertension, its degree of control, the pre-operative use of anti-hypertensive drugs, and the patient's risk of end-organ damage before using deliberate hypotension in a high-risk patient.	87 (84)	49	28*	17	2	3
Discuss with the surgeon whether deliberate hypotension is necessary.	82 (79)	57*	27	11	5	0
Maintain arterial pressure at higher levels in hypertensive patients to prevent risks to end organs.	86 (83)	35	38*	24	1	1
Use deliberate hypotension in high-risk patients only when the anesthesiologist and surgeon agree that its use is essential despite employing other means to minimize bleeding.	85 (82)	33	36*	14	12	5
Treat prolonged significant decreases in blood pressure.	86 (83)	74*	22	3	0	0
Adrenergic agonists may be used on a case-by-case basis when it is necessary to correct for hypotension.	86 (83)	34	51*	15	0	0
Intraoperative patient and head position devices and surgical staging						
Periodically monitor hemoglobin or hematocrit values during surgery in high-risk patients who experience substantial blood loss.	82 (79)	57*	32	11	0	0
Use transfusions of blood as deemed appropriate.	80 (77)	63*	35	3	0	0
Crystalloids or colloids alone or in combination may be used to maintain adequate replacement or intravascular volume.	78 (75)	27	37*	21	12	4
Position the high-risk patient so that the head is level with or higher than the heart when possible.	78 (75)	44	35*	19	3	0

Maintain the high-risk patient's head in a neutral forward position (e.g., without significant neck flexion, extension, lateral flexion, or rotation) when possible.	79 (76)	47	42*	9	3	0
Avoid direct pressure on the eye to prevent retinal artery occlusion (RAO).	78 (75)	82*	14	4	0	0
A head holder may be applied by the spine surgeon in patients in whom head positioning is challenging.	79 (76)	65*	32	4	0	0
Check the position of the eyes periodically during surgery to ensure the head has not moved and there is no eye compression.	78 (75)	67*	28	5	0	0
Staged spine procedures may be used on a case-by-case basis for high-risk patients.	78 (75)	50*	41	8	1	0
Postoperative management						
For the high-risk patient, conduct an ophthalmological assessment when the patient becomes alert (e.g., in the recovery room, intensive care unit, or nursing floor).	77 (74)	22	39*	18	16	5
If there is concern regarding potential visual loss, obtain an urgent ophthalmologic consultation to determine its cause.	77 (74)	66*	30	4	0	0
CT or MRI may be used on a case-by-case basis to rule out intracranial causes of visual loss as well as to visualize an abnormal (e.g., enhancing) optic nerve.	77 (74)	34	47*	18	1	0
Additional management may include optimizing hemoglobin or hematocrit values, hemodynamic status, and arterial oxygenation.	78 (75)	54*	38	8	0	0

***Median**

Table 4. NANOS Member Survey Results (Response Rate = %)

Recommendations	Answer Rate N (%)	Strongly Agree (%)	Agree (%)	Equivocal (%)	Disagree (%)	Strongly Disagree (%)
Preoperative patient evaluation and preparation						
Review a patient's preoperative history and perform an appropriate examination to identify patients with conditions such as preoperative anemia, vascular risk factors (e.g., hypertension, diabetes, peripheral vascular disease, coronary artery disease, previous stroke, carotid artery stenosis), obesity, and tobacco use.	119 (99)	55*	40	4	0	0
Inform patients that certain preoperative conditions may increase their risk of POVL in spine surgery. These include, but are not limited to those who are male, obese, have vascular disease risk factors such as hypertension and peripheral vascular disease, or have diabetic retinopathy.	118 (98)	40	42*	15	3	1
Inform patients in whom prolonged procedures, substantial blood loss, or both are anticipated that there may be an increased risk of POVL.	118 (98)	54*	42	3	2	0
Determine on a case-by-case basis whether or not to inform patients who are not anticipated to be "high-risk" for visual loss.	118 (98)	15	33	31*	17	4
Intraoperative blood pressure management						
Continually monitor systemic blood pressure in high-risk patients.	109 (91)	64*	32	4	0	0
Assess the patient's baseline blood pressure on a case-by-case basis.	108 (90)	27	41*	11	18	4

Determine on a case-by case basis whether deliberate hypotension should be used in high-risk patients.	109 (91)	38	35*	16	11	1
Check for the presence of pre-operative hypertension, its degree of control, the pre-operative use of anti-hypertensive drugs, and the patient's risk of end-organ damage before using deliberate hypotension in a high-risk patient.	109 (91)	57*	34	7	1	1
Discuss with the surgeon whether deliberate hypotension is necessary.	108 (90)	44	37*	13	4	2
Maintain arterial pressure at higher levels in hypertensive patients to prevent risks to end organs.	105 (88)	20	48*	31	1	0
Use deliberate hypotension in high-risk patients only when the anesthesiologist and surgeon agree that its use is essential despite employing other means to minimize bleeding.	109 (91)	35	51*	13	1	0
Treat prolonged significant decreases in blood pressure.	109 (91)	51*	43	6	0	0
Adrenergic agonists may be used on a case-by-case basis when it is necessary to correct for hypotension.	108 (90)	15	55*	28	2	1
Intraoperative patient and head position devices and surgical staging						
Periodically monitor hemoglobin or hematocrit values during surgery in high-risk patients who experience substantial blood loss.	106 (88)	42	44*	11	3	0
Use transfusions of blood as deemed appropriate.	106 (88)	52*	44	4	0	0
Crystalloids or colloids alone or in combination may be used to maintain adequate replacement or intravascular volume.	106 (88)	16	33	29*	20	2
Position the high-risk patient so that the head is level with or higher than the heart when possible.	98 (82)	29	42*	23	6	0
Maintain the high-risk patient's head in a neutral forward position (e.g., without significant neck flexion, extension, lateral flexion, or rotation) when possible.	100 (83)	37	45*	17	1	0
Avoid direct pressure on the eye to prevent retinal artery occlusion (RAO).	99 (83)	86*	13	1	0	0
A head holder may be applied by the spine surgeon in patients in whom head positioning is challenging.	101 (84)	33	50*	17	1	0
Check the position of the eyes periodically during surgery to ensure the head has not moved and there is no eye compression.	103 (86)	63*	35	2	0	0
Staged spine procedures may be used on a case-by-case basis for high-risk patients.	101 (84)	29	48*	23	1	0
Postoperative management						
For the high-risk patient, conduct an ophthalmological assessment when the patient becomes alert (e.g., in the recovery room, intensive care unit, or nursing floor).	101 (84)	22	37*	26	14	2
If there is concern regarding potential visual loss, obtain an urgent ophthalmologic consultation to determine its cause.	102 (85)	71*	27	2	0	0
CT or MRI may be used on a case-by-case basis to rule out intracranial causes of visual loss as well as to visualize an abnormal (e.g., enhancing) optic nerve.	103 (86)	32	54*	13	1	0
Additional management may include optimizing hemoglobin or hematocrit values, hemodynamic status, and arterial oxygenation.	103 (86)	61*	34	5	0	0

***Median**

Table 5. SNACC Member Survey Results (Response Rate = %)

Recommendations	Answer Rate N (%)	Strongly Agree (%)	Agree (%)	Equivocal (%)	Disagree (%)	Strongly Disagree (%)
Preoperative patient evaluation and preparation						
Review a patient's preoperative history and perform an appropriate examination to identify patients with conditions such as preoperative anemia, vascular risk factors (e.g., hypertension, diabetes, peripheral vascular disease, coronary artery disease, previous stroke, carotid artery stenosis), obesity, and tobacco use.	55 (96)	67*	25	4	4	0
Inform patients that certain preoperative conditions may increase their risk of POVL in spine surgery. These include, but are not limited to those who are male, obese, have vascular disease risk factors such as hypertension and peripheral vascular disease, or have diabetic retinopathy.	56 (98)	30	36*	21	11	2
Inform patients in whom prolonged procedures, substantial blood loss, or both are anticipated that there may be an increased risk of POVL.	56 (98)	46	36*	14	2	2
Determine on a case-by-case basis whether or not to inform patients who are not anticipated to be "high-risk" for visual loss.	57 (100)	25	51*	11	7	7
Intraoperative blood pressure management						
Continually monitor systemic blood pressure in high-risk patients.	46 (81)	85*	13	2	0	0
Assess the patient's baseline blood pressure on a case-by-case basis.	47 (82)	55*	23	2	9	11
Determine on a case-by case basis whether deliberate hypotension should be used in high-risk patients.	48 (84)	44	17*	6	21	13
Check for the presence of pre-operative hypertension, its degree of control, the pre-operative use of anti-hypertensive drugs, and the patient's risk of end-organ damage before using deliberate hypotension in a high-risk patient.	47 (82)	74*	17	2	4	2
Discuss with the surgeon whether deliberate hypotension is necessary.	48 (84)	71*	17	2	10	0
Maintain arterial pressure at higher levels in hypertensive patients to prevent risks to end organs.	49 (86)	65*	31	4	0	0
Use deliberate hypotension in high-risk patients only when the anesthesiologist and surgeon agree that its use is essential despite employing other means to minimize bleeding.	47 (82)	40	28*	13	13	6
Treat prolonged significant decreases in blood pressure.	48 (84)	100*	0	0	0	0
Adrenergic agonists may be used on a case-by-case basis when it is necessary to correct for hypotension.	47 (82)	64*	32	4	0	0
Intraoperative patient and head position devices and surgical staging						
Periodically monitor hemoglobin or hematocrit values during surgery in high-risk patients who experience substantial blood loss.	47 (82)	74*	26	0	0	0
Use transfusions of blood as deemed appropriate.	47 (82)	68*	30	0	2	0
Crystalloids or colloids alone or in combination may be used to maintain adequate replacement or intravascular volume.	47 (82)	45	36*	9	11	0
Position the high-risk patient so that the head is level with or higher than the heart when possible.	47 (82)	57*	26	15	2	0

Maintain the high-risk patient's head in a neutral forward position (e.g., without significant neck flexion, extension, lateral flexion, or rotation) when possible.	47 (82)	70*	30	0	0	0
Avoid direct pressure on the eye to prevent retinal artery occlusion (RAO).	47 (82)	87*	13	0	0	0
A head holder may be applied by the spine surgeon in patients in whom head positioning is challenging.	46 (81)	59*	37	4	0	0
Check the position of the eyes periodically during surgery to ensure the head has not moved and there is no eye compression.	47 (82)	79*	19	0	2	0
Staged spine procedures may be used on a case-by-case basis for high-risk patients.	46 (81)	57*	37	7	0	0
Postoperative management						
For the high-risk patient, conduct an ophthalmological assessment when the patient becomes alert (e.g., in the recovery room, intensive care unit, or nursing floor).	47 (82)	26	40*	19	15	0
If there is concern regarding potential visual loss, obtain an urgent ophthalmologic consultation to determine its cause.	46 (81)	78*	20	0	2	0
CT or MRI may be used on a case-by-case basis to rule out intracranial causes of visual loss as well as to visualize an abnormal (e.g., enhancing) optic nerve.	47 (82)	38	47*	15	0	0
Additional management may include optimizing hemoglobin or hematocrit values, hemodynamic status, and arterial oxygenation.	47 (82)	53*	40	6	0	0

*Median