Practice Advisory for the Prevention of Perioperative Peripheral Neuropathies

An Updated Report by the American Society of Anesthesiologists Task Force on Prevention of Perioperative Peripheral Neuropathies

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This document updates the "Practice Advisory for the Prevention of Perioperative Peripheral Neuropathies," adopted by the ASA in 1999 and published in 2000.*

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Methods

Definition of Peripheral Neuropathy

For this updated Advisory, *perioperative peripheral neuropathy* refers to postoperative signs and symptoms related to peripheral nerve injury (*e.g.*, brachial plexus, sciatic, and femoral). Symptoms may include, but are not limited to, paresthesias, muscle weakness, tingling, or pain in the extremities.

Purposes of the Advisory

The purposes of the Advisory are as follows: (1) to educate ASA members, (2) to provide a reference framework for individual practices, and (3) to stimulate the pursuit and evaluation of strategies that may prevent or reduce the frequency of occurrence or minimize the severity of peripheral neuropathies that may be related to perioperative positioning of patients.

Focus

Prevention of peripheral neuropathies is part of the larger process of perioperative care. This Advisory specifically focuses on perioperative positioning of the adult patient, use of protective padding, and avoidance of contact with hard surfaces or supports that may apply direct pressure on susceptible peripheral nerves. This Advisory does not focus on compartment syndromes or neuropathies that may be associated with anesthetic techniques (*e.g.*, spinal anesthesia).

This Advisory is intended to apply to adult patients who are or have been sedated or anesthetized. Areas in which these patients receive care include, but are not limited to, operating rooms and other anesthetizing locations, recovery rooms, intensive care units, outpatient procedural units, and office-based practices.

Application

The updated Advisory is intended for use by anesthesiologists or other providers working under the direction of anesthesiologists. It also may serve as a resource for other healthcare professionals.

Task Force Members and Consultants

The original Advisory was developed by an ASA-appointed task force of 10 members, consisting of anesthesiologists in

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private and academic practices from various geographic areas of the United States and two methodologists from the ASA Committee on Standards and Practice Parameters.

The task force developed the original Advisory *via* a six-step process. First, they reached consensus on the criteria for evidence. Second, original published articles from peer-reviewed journals relevant to perioperative peripheral neuropathy were evaluated. Third, consultants who had expertise or interest in peripheral neuropathy and who practiced or worked in various settings (*e.g.*, academic and private practice) were asked to do the following: (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 random samples of active members of the ASA. 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 to finalize the Advisory (appendix 1).

In 2009, the ASA Committee on Standards and Practice Parameters requested that evidence from two principal sources, scientific evidence and opinion-based evidence (appendix 2), for this Advisory be updated. The update consists of an evaluation of literature that includes new studies obtained after publication of the original Advisory.

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 further described.

Scientific Evidence

Study findings from published scientific literature were aggregated and are reported in summary form by evidence category, as described later. All literature (*e.g.*, randomized controlled trials, observational studies, and 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 within category 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.

Level 1. The literature contains observational comparisons (*e.g.*, cohort and 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 or 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. In addition, (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 using the terms described below.

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

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 because of methodological concerns (*e.g.*, confounding in study design or implementation).

Opinion-based Evidence

The original Advisory contained formal survey information collected from expert consultants and a random sample of

† Society for Ambulatory Anesthesia 14th Annual Meeting, Seattle, Washington, April 30, 1999.

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

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members of the ASA. 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, and editorials) was considered in the development of the original Advisory.

Survey responses from task force–appointed expert consultants are reported in summary form in the text, with a listing of consultant survey responses reported in appendix 2. In addition, survey responses from active ASA members are reported in summary form in the text, with a listing of survey responses reported in appendix 2.

Advisories

I. Preoperative History and Physical Assessment

Certain patient characteristics are associated with perioperative neuropathies. Although the literature is insufficient to examine the relationship between the performance of a preoperative history or physical assessment and the prevention of perioperative peripheral neuropathies (*category D evidence*), observational studies[1–8] have reported postoperative peripheral neuropathies occurring in patients with specific preexisting conditions (*e.g.*, diabetes mellitus, vascular disease, extremes of body weight, and age) (*category B2 evidence*). Such conditions often are noted in a patient's medical history or found during a physical assessment.

Ninety-three percent of the consultants who responded agree that a focused preoperative history may identify patients with an increased risk for the development of peripheral neuropathies during the perioperative period. Eighty-eight percent of the ASA membership respondents agree with the previous statement. The majority of consultants and responding ASA members who agree with the previous statement indicate that the following preexisting patient attributes are important to review: body habitus, preexisting neurologic symptoms, diabetes, peripheral vascular disease, alcohol dependence, and arthritis.

Eighty-eight percent of the responding consultants agree that a focused preoperative physical assessment may identify patients with an increased risk for the development of peripheral neuropathies during the perioperative period. Eighty percent of the ASA membership respondents agree with the previous statement.

Advisory for Preoperative History and Physical Assessment. Body habitus, preexisting neurologic symptoms, diabetes, peripheral vascular disease, alcohol dependence, arthritis, and gender (*e.g.*, male gender and its association with ulnar neuropathy) are important elements of a preoperative history. When judged appropriate, it would be helpful during a preoperative assessment to ascertain that patients can comfortably tolerate the anticipated operative position.

II. Specific Positioning Strategies for the Upper Extremities

Positioning Strategies to Reduce Perioperative Brachial Plexus Neuropathy: Seventeen articles[9–25] report brachial plexus injuries. Fourteen[9–16,18–20,22,23,25] were case reports or studies with descriptive information only. Eight of these articles[9,12–15,18,19,25] reported brachial plexus neuropathies occurring with arm abduction greater than 90°, and two[16,23] reported brachial plexus neuropathies occurring with arm abduction of 90°. Three articles[17,21,24] reported statistical comparisons, only one[17] of which was a randomized clinical trial.

Arm Abduction in a Supine Patient: One randomized controlled trial[17] comparing arm abduction of 90° with hands up compared with arms at the side reported no difference ($P = 0.51$) in the frequency of brachial plexus injury with patients in the supine position (*category C2 evidence*), and two nonrandomized comparative studies[21,24] corroborate the finding of no difference ($P = 0.12$ to $P = 0.61$) (*category C3 evidence*).

Ninety-two percent of the consultants and 96% of the ASA members agree that limiting abduction of the arm(s) in a supine patient may decrease the risk of brachial plexus neuropathy. Of those agreeing, 93% of the consultants and 84% of the ASA members indicate that the upper limit of abduction should be 90°. Seven percent of the consultants and 17% of the ASA members indicate an upper abduction limit of 60°.

Arm Abduction in a Prone Patient: One case report[9] indicated that a brachial plexus injury occurred when the patient was placed in a prone position with arms and shoulders abducted greater than 90° (*category B3 evidence*).

Eighty-eight percent of the consultants and 91% of the ASA members agree that limiting abduction of the arm or arms in a prone patient may decrease the risk of brachial plexus neuropathy. Of those agreeing, 67% of the consultants and 57% of the ASA members agree that the upper limit of abduction should be 90°.

Advisory for Positioning Strategies to Reduce Perioperative Brachial Plexus Neuropathy. Arm abduction in a supine patient should be limited to 90°. The task force notes that the prone position affects shoulder and brachial plexus mobility differently than does the supine position. These differences may allow patients to tolerate comfortably abduction of their arms greater than 90° when positioned prone.

Positioning Strategies to Reduce Perioperative Ulnar Neuropathy. Seven articles[7,8,26–30] report the occurrence of perioperative ulnar neuropathies. Three articles[27,28,30] were case reports, one[29] was a nonrandomized comparison of supination of the hands or forearms placed above the head with pronation of the hands, one[8] retrospectively compared patients placed in the supine position with those placed in the prone position, and one[26] prospectively compared tilted with nontilted positions.

Supine Patient with Arm on an Arm Board: The literature is insufficient to evaluate the impact of forearm positioning on an arm board on the occurrence of ulnar neuropathy in supine patients (*category D evidence*).

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Seventy-four percent of the consultants and 75% of the ASA members agree that specific forearm positions in a supine patient with an arm or arms abducted on an arm board may decrease the risk of ulnar neuropathy. Of those agreeing, 85% of the consultants and 87% of the ASA members selected the supinated and neutral forearm positions.

Supine Patient with Arms Tucked at Side: The literature is insufficient to evaluate the impact of arms being tucked at the side on the occurrence of ulnar neuropathy in supine patients (*category D evidence*).

Seventy-two percent of the consultants and 75% of the ASA members agree that specific forearm positions in a supine patient with an arm or arms tucked at the side may decrease the risk of ulnar neuropathy. Of those agreeing, 64% of the consultants and 63% of the ASA members selected the neutral forearm position.

Flexion of the Elbow: The literature is insufficient to evaluate the impact of elbow flexion on ulnar neuropathy (*category D evidence*).

Fifty-two percent of the consultants and 42% of the ASA members agree that flexion of the elbow may increase the risk of ulnar neuropathy. Of those agreeing, 72% of the consultants and 66% of the ASA members indicate that elbow flexion of greater than 90° may increase the risk of ulnar neuropathy.

Advisory for Positioning Strategies to Reduce Perioperative Ulnar Neuropathy

Supine Patient with Arm on an Arm Board: The upper extremity should be positioned to decrease pressure on the postcondylar groove of the humerus (ulnar groove). Either supination or the neutral forearm positions facilitates this action.

Supine Patient with Arms Tucked at Side: The forearm should be in a neutral position.

Flexion of the Elbow: Flexion of the elbow may increase the risk of ulnar neuropathy, but there is no consensus on an acceptable degree of flexion during the perioperative period.

Positioning Strategies to Reduce Perioperative Radial Neuropathy

The literature is insufficient to evaluate perioperative positioning strategies intended to reduce the occurrence of radial neuropathy (*category D evidence*).

Eighty-nine percent of the consultants and 86% of the ASA members agree that pressure in the spiral groove of the humerus from prolonged contact with a hard surface may increase the risk of radial neuropathy.

Advisory for Positioning Strategies to Reduce Perioperative Radial Neuropathy. Prolonged pressure on the radial nerve in the spiral groove of the humerus should be avoided.

Positioning Strategies to Reduce Perioperative Median Neuropathy

The literature is insufficient to evaluate perioperative positioning strategies intended to reduce the occurrence of median neuropathy (*category D evidence*).

Fifty-nine percent of the consultants and 62% of the ASA members agree that extension of the elbow in an anesthetized, supine patient beyond the normal range of extension that is comfortable during the preoperative examination may increase the risk of median neuropathy.

Advisory for Positioning Strategies to Reduce Perioperative Median Neuropathy. Extension of the elbow beyond the range that is comfortable during the preoperative assessment may stretch the median nerve.

Periodic Assessment of Upper Extremity Position during Procedures

The literature is insufficient to evaluate the efficacy of periodic assessment of patient position during a procedure in reducing the risk of upper extremity peripheral neuropathies (*category D evidence*).

Ninety-two percent of the consultants and 97% of the ASA members agree that upper extremity position should be periodically assessed during procedures.

Advisory for Periodic Assessment of Upper Extremity Position during Procedures. Periodic perioperative assessments may ensure maintenance of the desired position.

III. Specific Positioning Strategies for the Lower Extremities

Positioning Strategies to Reduce Perioperative Sciatic Neuropathy. Four articles[31–34] report the occurrence of postoperative sciatic neuropathy. One case report[31] notes sciatic neuropathy after vertical leg extension and maximum external rotation of the thighs in a lithotomy position, and a second case report[32] notes sciatic neuropathy after hip flexion of 90° in a sitting position (*category B3 evidence*). Two additional case reports[33,34] note sciatic neuropathies occurring in patients in the supine position with one hip increased (*category B3 evidence*).

The literature is insufficient to evaluate whether limiting stretching of the hamstring muscle group or limiting hip flexion is an effective strategy for reducing the incidence of sciatic neuropathy (*category D evidence*).

Forty-eight percent of the consultants and 57% of the ASA members agree that stretching of the hamstring muscle group (*e.g.,* biceps femoris muscle) beyond the normal range of motion that is comfortable during the preoperative assessment may increase the risk of sciatic neuropathy.

Fifty percent of the consultants and 52% of the ASA members agree that the risk of sciatic neuropathy in a patient who is positioned in a lithotomy position may be reduced if the degree of hip flexion is limited to 90°.

Advisory for Positioning Strategies to Reduce Perioperative Sciatic Neuropathy

Stretching of the Hamstring Muscle Group: Positions that stretch the hamstring muscle group beyond the range that is comfortable during the preoperative assessment may stretch the sciatic nerve.

Limiting Hip Flexion: Because the sciatic nerve or its branches cross both the hip and the knee joints, extension

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and flexion of these joints, respectively, should be considered when determining the degree of hip flexion.

Positioning Strategies to Reduce Perioperative Femoral Neuropathy

Three articles[35–37] report the occurrence of postoperative femoral neuropathy. One case report[35] notes femoral neuropathy occurring in patients placed in the lithotomy position with "excessive" hip abduction and external rotation (*category B3 evidence*). A second case report[36] indicates femoral neuropathy occurring in a patient placed in a lithotomy position with "exaggerated" hip rotation and swing stirrups (*category B3 evidence*). A third case report[37] indicates femoral neuropathy occurring in a patient placed in a lithotomy position with "extreme" hip flexion and abduction (*category B3 evidence*).

Forty percent of the consultants and 49% of the ASA members agree that extension of the hip in an anesthetized, supine patient beyond the normal range of extension that is comfortable during the preoperative examination (*e.g.,* hyperlordosis) may increase the risk of femoral neuropathy. Fifty-one percent of the consultants and 44% of the ASA members were undecided.

Forty percent of the consultants and 43% of the ASA members agree that the risk of femoral neuropathy may be reduced if the degree of hip flexion is limited to 90°. Forty-four percent of the consultants and 29% of the ASA members agree that the risk of femoral neuropathy in a patient placed in a lithotomy position is not increased with any degree of hip flexion.

Advisory for Positioning Strategies to Reduce Perioperative Femoral Neuropathy. Neither extension nor flexion of the hip increases the risk of femoral neuropathy.

Positioning Strategies to Reduce Perioperative Peroneal (Fibular) Neuropathy. Case reports[31,38,39] indicate peroneal neuropathy occurring after compression on the peroneal nerve secondary to placement of patients in a lithotomy position (*category B3 evidence*).

Ninety-two percent of the consultants and 95% of the ASA members agree that pressure near the fibular head from contact with a hard surface or a rigid support may increase the risk of peroneal neuropathy.

Advisory for Positioning Strategies to Reduce Perioperative Peroneal Neuropathy. Prolonged pressure on the peroneal nerve at the fibular head should be avoided.

IV. Protective Padding

Protective padding is intended to protect the patient from perioperative neuropathies. Ten articles[10,13,27,28,40–45] report peripheral neuropathies occurring when upper extremity protective padding was used. Three[10,13,44] are case reports of brachial plexopathy, five[27,28,42,43,45] are case reports of ulnar neuropathy, and one[40] is a case report of anterior interosseous nerve injury (*category B3 evidence*). One retrospective assessment[41] of the placement of towels under the scapula during median sternotomy reports 4 cases of brachial plexus injury (*category B2 evidence*). However, these studies do not imply that protective padding was a cause of peripheral neuropathies, nor do they imply that the padding was used inappropriately. No studies addressed the use of chest ("axillary") rolls to reduce perioperative peripheral neuropathies (*category D evidence*). In addition, no studies addressed lower extremity protective padding to reduce the occurrence of perioperative peripheral neuropathies (*category D evidence*).

Eighty-nine percent of the consultants and 89% of the ASA members agree that padded armboards may decrease the risk of upper extremity neuropathies.

Seventy-eight percent of the consultants and 87% of the ASA members agree that the use of a chest roll placed under the "downside" (dependent) lateral thorax in a patient who is positioned laterally may decrease the risk of brachial plexus neuropathy in the down arm.

Sixty-eight percent of the consultants and 78% of the ASA members agree that the use of specific padding (*e.g.,* foam or gel pads) at the elbow may decrease the risk of ulnar neuropathy.

Ninety-four percent of the consultants and 91% of the ASA members agree that the use of specific padding to prevent contact of the peroneal nerve (at the fibular head) with a hard surface may decrease the risk of peroneal neuropathy.

Sixty-eight percent of the consultants and 60% of the ASA members agree that, in some circumstances, the use of padding may increase the risk of peripheral neuropathies.

Advisory for Protective Padding

Padded Arm Boards: Padded arm boards may decrease the risk of upper extremity neuropathy.

Chest Rolls: The use of chest rolls in the laterally positioned patient may decrease the risk of upper extremity neuropathy.

Padding at the Elbow: Padding at the elbow may decrease the risk of upper extremity neuropathy.

Padding to Protect the Peroneal (Fibular) Nerve: The use of specific padding to prevent pressure of a hard surface against the peroneal nerve at the fibular head may decrease the risk of peroneal neuropathy.

Complications from the Use of Padding: The inappropriate use of padding (*e.g.*, padding too tight) may increase the risk of perioperative neuropathy.

V. Equipment

No articles prospectively examined the impact of equipment or supports as a direct cause of perioperative peripheral neuropathies (*category D evidence*). Eleven case reports[20,30,46–54] indicate the postoperative occurrence of peripheral neuropathies after the use of upper extremity equipment or supports. Five case reports[30,46,49,51,53] described radial or ulnar nerve damage occurring when a blood pressure monitoring device was used intraoperatively (*category B3 evidence*). Two case reports[20,54] described brachial plexus neuropathies occurring when shoulder braces or rests were used (*category B3 evidence*). One case re-

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port[50] described isolated radial nerve palsy occurring in a prone patient with an arm abducted over a Foster frame, and one case report[48] described radial neuropathy occurring in a supine patient undergoing coronary artery bypass grafting with an arm compressed by a self-retaining sternal retractor (*category B3 evidence*). One nonrandomized study[55] with observational findings reported a 4.9% frequency of upper limb nerve injuries when an arm board was used (*category B2 evidence*).

Fifteen case reports described femoral or peroneal neuropathies occurring with the use of leg holders,[56] stirrups,[36,57,58] surgical stockings,[59] pneumatic compression devices,[60] retractors,[61–68] and padded slings[69] (*category B3 evidence*). One study[70] with observational findings reported femoral neuropathies occurring at a lower rate during a period when the use of self-retaining retractors was not used compared with an earlier period when self-retaining retractors were used. One case of lateral popliteal nerve palsy was reported as a complication after the use of a continuous passive-motion knee machine (*category B3 evidence*).[71] One nonrandomized comparative study[72] reports more postpartum neurologic dysfunction in parturients placed in a lithotomy position with stirrups *versus* without stirrups (*category B2 evidence*). One nonrandomized comparison study[73] of patients in the lithotomy position reports more lower extremity neuropathy when patients' legs are wrapped *versus* not wrapped (*category B2 evidence*).

Thirty-nine percent of the consultants and 30% of the ASA members agree that the use of an automated blood pressure cuff on the arm may *increase* the risk of ulnar neuropathy. Thirty-nine percent of consultants and 30% of the ASA members agree that the use of an automated blood pressure cuff on the arm may *increase* the risk of radial neuropathy. Twenty-nine percent of the consultants and 20% of the ASA members agree that the use of an automated blood pressure cuff on the arm may *increase* the risk of median neuropathy.

Sixty-six percent of the consultants and 66% of the ASA members agree that shoulder braces (commonly placed over the acromioclavicular joint) to prevent a patient from sliding cephalad when placed in a steep head-down position may *increase* the risk of brachial plexus neuropathy.

Advisory for Equipment. The use of properly functioning automated blood pressure cuffs on the arm (*i.e.*, placed above the antecubital fossa) does not change the risk of upper extremity neuropathy. The use of shoulder braces in a steep head-down position may increase the risk of perioperative neuropathies.

VI. Postoperative Physical Assessment

The literature is insufficient to evaluate whether performing an early postoperative physical assessment reduces the severity of complications associated with perioperative peripheral neuropathies (*category D evidence*). However, four case reports,[42,74–76] and four descriptive studies[72,77–79] described the detection of a peripheral neuropathy during postoperative assessment (*category B2–B3 evidence*).

Seventy-two percent of the consultants and 67% of the ASA members agree that examining the patient in the postanesthesia care unit (PACU) may lead to early recognition of peripheral neuropathy.

Advisory for Postoperative Physical Assessment. A simple postoperative assessment of extremity nerve function may lead to early recognition of peripheral neuropathies.

VII. Documentation

The literature is insufficient to evaluate the impact of documentation of specific perioperative positioning actions as they may relate to peripheral neuropathies (*category D evidence*).

Eighty-eight percent of the consultants and 93% of the ASA members agree that documentation on an anesthetic record of specific positioning actions during the care of a patient is important. Agreement of the majority of consultants and ASA members with the previous statement indicates that, when appropriate, it is important to document the following: (1) overall patient position (*e.g.*, supine, prone, lateral, or lithotomy); (2) position of arms; (3) position of lower extremities; (4) use of specific padding at the elbow or over the fibular head; (5) specific positioning action(s) taken or used during the procedures, as indicated by findings on the preoperative assessment; and (6) presence or absence of signs or symptoms of peripheral neuropathy in the PACU.

Advisory for Documentation. Documentation of specific perioperative positioning actions may be useful for continuous improvement processes and may result in improvements by (1) helping practitioners focus attention on relevant aspects of patient positioning and (2) providing information on positioning strategies that eventually leads to improvements in patient care.

Appendix 1: Summary of Advisory Statements

I. Preoperative History and Physical Assessment

- When judged appropriate, it is helpful to ascertain that patients can comfortably tolerate the anticipated operative position.§

II. Specific Positioning Strategies for the Upper Extremities

- Arm abduction in supine patients should be limited to 90°.
- Patients who are positioned prone may comfortably tolerate arm abduction greater than 90°.
- *Supine Patient with Arm on an Arm Board*
  - The upper extremity should be positioned to decrease pressure on the postcondylar groove of the humerus (ulnar groove).

§ Body habitus, preexisting neurologic symptoms, diabetes, peripheral vascular disease, alcohol dependence, arthritis, and gender (*e.g.*, male gender and its association with ulnar neuropathy) are important elements of a preoperative history.

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- Either supination or the neutral forearm positions facilitates this action.

- *Supine Patient with Arms Tucked at Side*
  - The forearm should be in a neutral position.
  - Flexion of the elbow may increase the risk of ulnar neuropathy, but there is no consensus on an acceptable degree of flexion during the perioperative period.
  - Prolonged pressure on the radial nerve in the spiral groove of the humerus should be avoided.
  - Extension of the elbow beyond the range that is comfortable during the preoperative assessment may stretch the median nerve.
  - Periodic perioperative assessments may ensure maintenance of the desired position.

III. Specific Positioning Strategies for the Lower Extremities

- *Stretching of the Hamstring Muscle Group*
  - Positions that stretch the hamstring muscle group beyond the range that is comfortable during the preoperative assessment may stretch the sciatic nerve.

- *Limiting Hip Flexion*
  - Because the sciatic nerve or its branches cross both the hip and the knee joints, extension and flexion of these joints, respectively, should be considered when determining the degree of hip flexion.
  - Neither extension nor flexion of the hip increases the risk of femoral neuropathy.
  - Prolonged pressure on the peroneal nerve at the fibular head should be avoided.

IV. Protective Padding

- *Padded Arm Boards*
  - Padded arm boards may decrease the risk of upper extremity neuropathy.

- *Chest Rolls*
  - The use of chest rolls in the laterally positioned patient may decrease the risk of upper extremity neuropathy.

- *Padding at the Elbow*
  - Padding at the elbow may decrease the risk of upper extremity neuropathy.

- *Padding to Protect the Peroneal (Fibular) Nerve*
  - The use of specific padding to prevent pressure of a hard surface against the peroneal nerve at the fibular head may decrease the risk of peroneal neuropathy.

- *Complications from the Use of Padding*
  - The inappropriate use of padding (*e.g.*, padding too tight) may increase the risk of perioperative neuropathy.

‖ Unless otherwise specified, outcomes for the listed interventions refer to the occurrence of peripheral neuropathy.

V. Equipment

- The use of properly functioning automated blood pressure cuffs on the arm (*i.e.*, placed above the antecubital fossa) does not change the risk of upper extremity neuropathy.
- The use of shoulder braces in a steep head-down position may increase the risk of perioperative neuropathies.

VI. Postoperative Assessment

- A simple postoperative assessment of extremity nerve function may lead to early recognition of peripheral neuropathies.

VII. Documentation

- Documentation of specific perioperative positioning actions may be useful for continuous improvement processes and may result in improvements by: (1) helping practitioners focus attention on relevant aspects of patient positioning and (2) providing information on positioning strategies that eventually leads to improvements in patient care.

Appendix 2: Methods and Analyses

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 positioning strategies and perioperative peripheral neuropathy. The evidence linkage interventions are listed as follows.‖

I. Preoperative History and Physical Assessment
   A. A focused preoperative history and physical assessment.

II. Specific Positioning Strategies for the Upper Extremities
   A. Brachial plexus neuropathy
      1. Abduction of 90° or less *versus* greater than 90°
      2. Supination of forearm *versus* pronation (and its subsequent effect on rotation of the humerus)
   B. Ulnar neuropathy at the elbow
      1. Flexion/extension of the elbow of 90° or less *versus* greater than 90°
      2. Patient in the supine position
      3. Forearm on an arm board: supination *versus* pronation of the forearm
      4. Arms tucked at the side: supination *versus* pronation of the forearm
   C. Radial neuropathy in the arm
      1. Avoidance of pressure on arm from contact with hard surfaces
   D. Median neuropathy at the elbow
      1. Patient in supine position

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a. Flexion/extension of the elbow of 90° or less *versus* greater than 90°

III. Specific Positioning Strategies for the Lower Extremities
A. Sciatic neuropathy
1. Stretching of the hamstring muscle (*e.g.*, biceps femorous muscle) beyond a comfortable range of motion
2. Hip flexion of 120° or less *versus* greater than 120°
B. Femoral neuropathy
1. Hip flexion of 90° or less
C. Peroneal (fibular) neuropathy
1. Avoidance of contact with hard surfaces or supports that apply direct pressure on the fibular head
2. Avoidance of contact with hard surfaces or supports that apply direct pressure on the lateral tibia

IV. Protective Padding
A. Upper extremity
1. Padded arm boards
2. Specific padding (*e.g.*, foam or gel pads) at the elbow
3. For a patient in a lateral position, the use of a chest roll positioned under the chest (*vs.* a chest roll placed under the axilla) to protect the brachial plexus
4. Avoidance of padding that is excessively tight or restrictive (*e.g.*, on the elbow)
B. Lower extremity
1. Specific padding between the outside of the leg below the knee to prevent contact of the peroneal nerve (at the fibular head) with a hard surface
2. Avoidance of padding that is excessively tight or restrictive

V. Equipment
A. Placed in the upper extremity
1. Use of shoulder braces (commonly placed over the acromioclavicular joint) to prevent a patient from sliding cephalad when placed in a steep head-down position
B. Blood pressure cuff
1. Automated blood pressure cuff (*vs.* manual blood pressure cuff monitoring)
2. Blood pressure cuff placed on the arm (*vs.* blood pressure cuff placed on the forearm)
3. Placed on the lower extremity
a. Avoidance of contact with hard surfaces or supports that apply direct pressure on the fibular head
b. Avoidance of contact with hard surfaces or supports that apply direct pressure on the lateral tibia

VI. Postoperative Assessment
A. Postoperative physical assessment to detect peripheral neuropathies.

VII. Documentation
A. Documentation of specific perioperative positioning actions to improve patient care.

For literature review, potentially relevant clinical studies were identified *via* electronic and manual searches of the literature. The updated electronic search covered a 12-yr period from 1999 through 2010. The manual search covered a 21-yr period from 1990 through 2010. More than 50 new citations that addressed topics related to the evidence linkages were initially identified. These articles were reviewed and combined with pre-1999 articles used in the original Advisory, resulting in 86 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.*, a 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/A663.

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 only contain 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, which may occur in review articles or follow-up studies that summarize previous findings. (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 of the few studies meeting all four criteria, the published literature could not be used as a source of quantitative support.

In conclusion, the current literature has not been helpful in determining the efficacy of perioperative positioning techniques in reducing the occurrence of peripheral neuropathies. Until additional controlled studies are conducted, evidence from other 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 positioning techniques for the prevention of peripheral neuropathies focuses on improving research design and methods by concentrating on single interventions and recognizing confounding influences on outcomes (*e.g.*, type or duration of surgery may influence the incidence or severity of

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perioperative peripheral neuropathies independent of patient position).

Consensus-based Evidence

For the original Advisory, consensus was obtained from multiple sources, including the following: (1) survey opinion from consultants who were selected based on their knowledge or expertise in perioperative positioning and peripheral neuropathy, (2) survey opinions from a randomly selected sample of active members of the ASA, (3) testimony from attendees of a publicly held open forum at a national convention, (4) Internet commentary, and (5) task force member opinion and interpretation. The rate of return was 56.0% (84/150) for consultants and 28.9% (433/1,500) for membership respondents.

Results of the original surveys are reported in tables 1–3 and in the text of the Advisory. The majority of consultants and ASA membership respondents agreed with the following survey items: (1) a focused preoperative medical history and a focused preoperative examination to identify patients at risk for the development of peripheral neuropathies during the perioperative period; (2) upper extremity position should be periodically assessed during procedures; (3) limiting abduction of the arm(s) in a supine or prone patient may decrease the risk of brachial plexus neuropathy; (4) specific forearm position(s) in a supine patient with arm(s) tucked at the side or abducted on an arm board may decrease the risk of ulnar neuropathy; (5) pressure in the spiral groove of the humerus from prolonged contact with a hard surface may increase the risk of radial neuropathy; (6) extension of the elbow in an anesthetized supine patient beyond the normal range of extension that is comfortable during the preoperative examination may increase the risk of median neuropathy; (7) pressure near the fibular head from contact with a hard surface or a rigid support may increase the risk of peroneal neuropathy; (8) padded arm boards may decrease the risk of upper extremity neuropathies; (9) a chest roll placed under the "downside" (dependent) lateral thorax in a patient who is positioned laterally may decrease the risk of brachial plexus neuropathy in the down arm; (10) specific padding (*e.g.*, foam or gel pads) at the elbow may decrease the risk of ulnar neuropathy; (11) specific padding to prevent contact of the peroneal nerve (at the fibular head) with a hard surface may decrease the risk of peroneal neuropathy; (12) in some circumstances, the use of padding may increase the risk of peripheral neuropathies; (13) shoulder braces (commonly placed over the acromioclavicluar joint) to prevent a patient from sliding cephalad when placed in a steep head-down position may increase the risk of brachial plexus neuropathy; (14) examining the patient in the PACU may lead to early recognition of peripheral neuropathy; and (15) documentation on an anesthetic record of specific positioning actions during the care of a patient is important. Items for which no majority agreement was indicated were as follows: (1) flexion of the elbow may increase the risk of ulnar neuropathy; (2) stretching of the hamstring muscle group (*e.g.*, biceps femoris muscle) beyond the normal range of motion that is comfortable during the preoperative assessment may increase the risk of sciatic neuropathy; (3) extension of the hip in an anesthetized supine patient beyond the normal range of extension that is comfortable during the preoperative examination (*e.g.*, hyperlordosis) may increase the risk of femoral neuropathy; and (4) the use of an automated blood pressure cuff on the arm may increase the risk of ulnar, radial, or median neuropathy.

Consultants and ASA membership respondents who agreed with the previously described survey items responded to specific item-related topics. Most of these respondents agreed with the following items: (1) preexisting patient attributes that are important to review during a preoperative history include, but are not limited to, body habitus, preexisting neurologic symptoms, diabetes, peripheral vascular disease, alcohol dependence, and arthritis; (2) during a patient examination, it is important to assess limitations to joint range of motion in the elbow and/or shoulder, range of motion of an arthritic neck, range of motion of the hip and knee joints (for placing patients in a lateral or lithotomy position), ability to extend hips (for placing patients in a supine position), and flexibility of the hamstring muscle group (for placing patients in a lateral or lithotomy position); (3) the upper limit of abduction of the arm(s) in a supine or prone patient should be 90°; (4) in a supine patient with arm(s) tucked at the side, the forearm in the neutral position may decrease the risk of ulnar neuropathy; (5) in a supine patient with arm(s) abducted on an arm board, the forearm in the supinated position may decrease the risk of ulnar neuropathy; (6) elbow flexion of greater than 90° may increase the risk of ulnar neuropathy; (7) the risk of sciatic neuropathy in a patient who is positioned in a lithotomy position may be reduced if the degree of hip flexion is limited to 90°; and (8) it is important to document overall patient position (*e.g.*, supine, prone, lateral, or lithotomy), position of arms, position of lower extremities, use of specific padding at the elbow or over the fibular head, specific positioning action(s) taken or used during a procedure as indicated by findings on a preoperative examination, and the presence or absence of signs or symptoms of peripheral neuropathy in the PACU.

A majority was not obtained for the following items: (1) gender as an important attribute to review in a focused preoperative history, (2) flexibility of the hamstring muscle group (for placing patients in a lateral or lithotomy position) as important for assessing a preoperative examination, (3) the degree of hip flexion for reducing the risk of femoral neuropathy in a patient placed in a lithotomy position, and (4) the type of leg holder used for a patient in a lithotomy position as an important attribute to document.

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Table 1. Consultant Survey of Evidence Linkages

Type of Neuropathy	Positioning Intervention to Decrease Risk of Peripheral Neuropathy	No. of Responses	% Response		
			Agree	Disagree	Do Not Know
NA	A focused preoperative history	84	93	6	1
NA	A focused preoperative examination	82	88	5	7
Upper extremity	Periodic assessment of upper extremity position during procedures	83	92	5	3
Brachial plexus	Limiting abduction of the arm(s) in a supine patient	82	92	1	7
	Limiting abduction of the arm(s) in a prone patient	81	88	5	7
Ulnar	Specific forearm position(s) in a supine patient with arm(s) tucked at the side	83	72	11	17
	Specific forearm position(s) in a supine patient who has arm(s) abducted on an arm board	83	74	16	10
	Flexion of the elbow	81	52	20	28
Radial	Pressure in the spiral groove of the humerus from prolonged contact with a hard surface	82	89	2	9
Median	Extension of the elbow in an anesthetized supine patient beyond the normal range of extension that is comfortable during the preoperative examination	82	59	7	34
Sciatic	In a patient who is positioned in a lateral or lithotomy position, stretching of the hamstring muscle group beyond a comfortable range	81	48	9	43
Femoral	Extension of the hip in a supine patient beyond a comfortable range	83	40	10	50
Peroneal	Pressure near the fibular head from contact with a hard surface or a rigid support	83	92	0	8
Upper extremity	Padded arm boards	83	89	1	10
Brachial plexus	A chest roll placed under the “downside” (dependent) lateral thorax in a patient who is positioned laterally	83	78	7	15
Ulnar	Specific padding (*e.g.*, foam or gel pads) at the elbow	83	67	10	23
Peroneal	Specific padding to prevent contact of the peroneal nerve (at the fibular head) with a hard surface	82	94	1	5
Peroneal	Padding in some circumstances may increase peripheral neuropathy	81	68	14	18
Brachial plexus	Shoulder braces to prevent a patient from sliding cephalad when placed in a steep head-down position may increase peripheral neuropathy	83	66	9	25
Ulnar	Automated blood pressure cuff on the arm may increase risk of neuropathy	82	39	26	35
Radial	Automated blood pressure cuff on the arm may increase risk of neuropathy	83	39	21	40
Median	Automated blood pressure cuff on the arm may increase risk of neuropathy	82	29	29	42
	Examining a patient in the PACU may lead to early recognition of neuropathies	83	72	17	11
	Documentation on an anesthetic record of specific positioning actions	84	88	8	4

NA = not applicable; PACU = postanesthesia care unit.

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Table 2. Membership Survey of Evidence Linkages

Type of Neuropathy	Positioning Intervention to Decrease Risk of Peripheral Neuropathy	No. of Responses	% Response		
			Agree	Disagree	Do Not Know
NA	A focused preoperative history	433	88	5	7
NA	A focused preoperative examination	429	80	9	11
Upper extremity	Periodic assessment of upper extremity position during procedures	425	97	1	2
Brachial plexus	Limiting abduction of the arm(s) in a supine patient	431	96	2	2
Brachial plexus	Limiting abduction of the arm(s) in a prone patient	432	91	4	5
Ulnar	Specific forearm position(s) in a supine patient with arm(s) tucked at the side	424	75	11	14
Ulnar	Specific forearm position(s) in a supine patient who has arm(s) abducted on an arm board	426	75	11	14
Ulnar	Flexion of the elbow	426	42	28	30
Radial	Pressure in the spiral groove of the humerus from prolonged contact with a hard surface	425	86	3	11
Median	Extension of the elbow in a supine patient beyond the normal range of extension that is comfortable during the preoperative examination	424	62	7	31
Sciatic	In a patient who is positioned in a lateral or lithotomy position, stretching of the hamstring muscle group beyond a range that is comfortable during a preoperative examination	423	57	4	39
Femoral	Extension of the hip in a supine patient beyond a range that is comfortable during a preoperative examination	424	49	7	44
Peroneal	Pressure near the fibular head from contact with a hard surface or a rigid support	429	95	1	4
Upper extremity	Padded arm boards	428	89	5	6
Brachial plexus	A chest roll placed under the "downside" (dependent) lateral thorax in a patient who is positioned laterally	427	87	5	8
Ulnar	Specific padding (*e.g.*, foam or gel pads) at the elbow	429	78	10	12
Peroneal	Specific padding to prevent contact of the peroneal nerve (at the fibular head) with a hard surface	429	91	3	6
	Padding in some circumstances may increase peripheral neuropathy	427	60	12	28
Brachial plexus	Shoulder braces to prevent a patient from sliding cephalad when placed in a steep head-down position may increase peripheral neuropathy	422	66	8	26
Ulnar	Automated blood pressure cuff on the arm may increase risk of neuropathy	428	30	36	34
Radial	Automated blood pressure cuff on the arm may increase risk of neuropathy	428	30	31	39
Median	Automated blood pressure cuff on the arm may increase risk of neuropathy	429	20	39	41
	Examining a patient in the PACU may lead to early recognition of neuropathies	424	67	19	14
	Documentation on an anesthetic record of specific positioning actions	424	93	4	3

NA = not applicable; PACU = postanesthesia care unit.

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Table 3. Item Responses for Consultants and ASA Members*

Survey Item	Consultants	Membership
1. For a preoperative history, the following attributes are important to review:		
Preexisting neurologic symptoms	78 (96)	383 (96)
Diabetes mellitus	78 (90)	383 (86)
Body habitus	78 (83)	383 (88)
Peripheral vascular disease	78 (74)	383 (77)
Arthritis	78 (56)	383 (66)
Alcohol dependence	78 (56)	383 (52)
Gender	78 (42)	380 (43)
2. In a patient examination, it is important to assess the following:		
Limitations to joint range of motion in the elbow and/or shoulder	74 (88)	343 (94)
Range of motion of an arthritic neck	73 (85)	345 (93)
Range of motion of the hip and knee joints (for placing patients in a lateral or lithotomy position)	69 (68)	325 (73)
Ability to extend hips (for placing patients in a supine position)	67 (55)	323 (58)
Flexibility of the hamstring muscle group (for placing patients in a lateral or lithotomy position)	67 (49)	321 (55)
3. The upper limit of abduction of the arm(s) in a supine patient should be:		
60°	72 (7)	405 (16)
90°	72 (93)	405 (84)
4. The upper limit of abduction of the arm(s) in a prone patient should be:		
60°	70 (33)	387 (43)
90°	70 (67)	387 (57)
5. Which forearm position (in a supine patient with arm(s) tucked at the side) do you believe may decrease the risk of ulnar neuropathy?		
Supinated	59 (27)	312 (26)
Pronated	59 (9)	312 (11)
Neutral	59 (64)	312 (63)
6. Which forearm position (in a supine patient who has arm[s] abducted on an arm board) do you believe may decrease the risk of ulnar neuropathy?		
Supinated	60 (62)	315 (59)
Pronated	60 (15)	315 (13)
Neutral	60 (23)	315 (28)
7. What degree of elbow flexion may increase the risk of ulnar neuropathy?		
45°	40 (15)	171 (14)
90°	40 (13)	171 (20)
>90°	40 (72)	171 (66)
8. The risk of sciatic neuropathy in a patient who is positioned in a lithotomy position may be reduced if the degree of hip flexion is limited to:		
60°	68 (19)	346 (28)
90°	68 (50)	346 (52)
120°	68 (13)	346 (12)
Risk is not increased with any degree of hip flexion	68 (18)	346 (8)
9. The risk of femoral neuropathy in a patient placed in a lithotomy position may be reduced if the degree of hip flexion is limited to:		
60°	62 (7)	327 (20)
90°	62 (40)	327 (43)
120° (*e.g.*, exaggerated lithotomy)	62 (10)	327 (8)
Risk is not increased with any degree of hip flexion	62 (43)	327 (29)
10. The following attributes are important to document:		
Overall patient position (*e.g.*, supine, prone, lateral, or lithotomy)	74 (100)	392 (99)
Position of arms	74 (84)	393 (81)
Position of lower extremities	74 (66)	393 (66)
Use of specific padding at the elbow or over the fibular head	74 (82)	392 (73)
For a patient in a lithotomy position, the type of leg holder used	74 (51)	393 (39)
Specific positioning action(s) taken or used during a procedure, as indicated by findings on a preoperative examination	74 (87)	393 (79)
Presence or absence of signs or symptoms of peripheral neuropathy in the PACU	74 (58)	393 (58)

* Data are given as number (percentage) of each group.

ASA = American Society of Anesthesiologists; PACU = postanesthesia care unit.

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