

THE AANA FOUNDATION CLOSED MALPRACTICE CLAIMS STUDY ON NERVE INJURIES DURING ANESTHESIA CARE

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Anesthesia-associated nerve injury is a common cause of patient morbidity and litigation. To identify factors associated with perioperative nerve injuries and rationalize preventive strategies, 44 cases from the American Association of Nurse Anesthetists (AANA) Foundation Closed Malpractice Claims Database pertaining to nerve injuries in which nurse anesthetists provided care were analyzed. Emerging patterns and themes related to the development of injury were identified.

The database is a collection of medical liability claims filed against CRNAs insured by the St Paul Fire and Marine Insurance Company; 44 claims of anesthesia-related nerve injury were analyzed. The most common injury was to the brachial plexus (15 [34%]), followed by ulnar nerve injury (7 [16%]), radial nerve injury (5 [11%]), peroneal nerve injury

(4 [9%]), paraplegia (4 [9%]), lumbosacral injury (3 [7%]), and a variety of "other" injuries (8 [18%]). These numbers and percentages total more than 44 (100%) as some patients incurred multiple injuries. Documentation on the anesthesia record of the use of intraoperative protective padding and patient position was lacking or inadequate in a majority of the claims.

Effective strategies for the prevention of nerve injury during anesthesia are reviewed. Abnormal body habitus, several disease states, anesthesia technique, improper positioning, lack of adequate padding, and tourniquet use have been implicated as risk factors.

Key words: Closed claims analysis, complications, peripheral nerve injury.

Findings related to perioperative nerve injuries involving Certified Registered Nurse Anesthetists (CRNAs) as a result of the ongoing analysis of closed malpractice claims files from the St Paul Fire and Marine Insurance Company were reported. During the 2000-2001 period, a team of CRNA investigators examined closed claim files that involved incidents from 1989 through 1997. Findings of the American Association of Nurse Anesthetists Foundation (AANAF) Closed Malpractice Claims Study began appearing in the August 2001 issue of the *AANA Journal*.¹

Although the inherent limitations of closed claims analysis are well appreciated (eg, absence of a denominator, reviewer hindsight bias, inconsistent patient injury reporting, inability to affirm cause-effect relationships, difficulty isolating antecedents), its strengths lie in accessing low rate-of-occurrence events (eg, catastrophic outcome), identifying emerging themes, and recognizing potential associative factors.

The matter of nerve injury has proven to be a particular conundrum. Although nerve injuries are significant sources of patient injury, the complexities and

ambiguities of risk factors, intraoperative events, and mechanisms of injury have proved befuddling to researchers and clinicians alike.²⁻⁴ Certainly one compelling complicating factor is the inability of the patient to communicate during general anesthesia, during deep sedation, or once a regional technique has "set up" so that compression, ischemia, or some other event is affecting a part of a nerve's distribution.

The present study involved the critical analysis of 44 cases of nerve injury that are components of the current closed malpractice claims contained within the AANAF Closed Malpractice Claims Database. We describe the method of analysis and emerging findings and make recommendations that clinicians should consider incorporating into their practice to minimize the risks of peripheral nerve injury during anesthetic intervention.

AANAF Closed Malpractice Claims Study Methodology

In 1995, a research team of 8 CRNAs was selected by the AANAF Board of Directors to conduct its closed claims study. These investigators represent a geographic and practice setting cross-section of CRNAs.

Following the initial challenges of developing, piloting, and refining a research instrument, the team collected data from St Paul Company files. The research tool captured more than 150 data points in the following areas: patient demographics, anesthesia provider information, anesthesia care data, preexisting health conditions, the basis for the lawsuit, the disposition of the claim, and a summary of the relevant events.

A loss control analyst at the St Paul Fire and Marine Insurance Company conducted a computerized data search of national St Paul regional service centers. All medical liability claims that were filed against CRNAs who were insured by this company that closed before data collection were sought. Due to the “long-tail” nature of malpractice insurance coverage, most of the claims concerned incidents that occurred many years before data collection. More than 5 years may have elapsed from the time of the incident to claim closure. Contents of closed claims filed included medical records, expert reviews, narrative statements, correspondence between legal counsel and claims representative, and cost settlement or jury award information.

The following are the inclusion criteria for the AANAF Closed Malpractice Claims Study: (1) only closed claims involving CRNAs and (2) complete anesthesia records included in the file. Dental claims were excluded since the mechanism of injury was obvious.

Two independent teams of investigators subsequently reexamined the 44 cases of peripheral nerve injury. This secondary analysis was directed at determining the variables and factors listed in Table 1, using a careful content analysis. When a rare conflict or disagreement occurred between the independent analyses, the investigators discussed the area of conflict and reached resolution in each instance.

Results

This article provides an overview of the 44 cases of nerve injury contained within the total AANAF Closed Malpractice Claims Database (n = 223). The major injuries contained in the total database are death (71 [32%]), nerve injury (42 [19%]), and brain damage (27 [12%]). The distribution of cases of nerve injuries follows. The most common injury reported was a brachial plexus injury (15 [34%]). Following this category of injury were ulnar nerve injuries (7 [16%]), radial nerve injuries (5 [11%]), peroneal nerve injuries (4 [9%]), paraplegia (4 [9%]), and lumbosacral injuries (3 [7%]). (The numbers and percentages total more than 44 (100%) because some patients had more than one injury.) A wide variety of “other” injuries accounted for the remaining 8 (18%) that included the sciatic, peroneal, femoral, musculocutaneous, recur-

Table 1. Factors analyzed in each case

Age
Sex
Weight and body habitus
ASA physical status
Presence or absence of preoperative anesthetic evaluation
Procedure(s) performed
Type of anesthesia
Duration of anesthesia
Type of nerve injury
Coexisting disease and risk factors
Documentation of positioning
Documentation of padding
Judgment as to whether standard of care was provided

rent laryngeal, median, and facial nerves.

Regarding the proportion of claims filed related to sex, 20 (45%) of 44 were filed by males and 22 (50%) by females, a near identical representation. In 2 cases (5%), the remaining subjects’ sex was not indicated. The age range of subjects was 9 months to 84 years. The body mass index (BMI) was high (>31 kg/m²) in 7 (16%) of the subjects and low (<24 kg/m²) in 9 (20%) of the subjects.

Documentation of patient positioning and the use of protective padding by the CRNA was lacking in a majority of the claims filed. Reviewers found that documentation of patient positioning was judged as “adequate” in only 12 (27%) of 44 claims studied, while protective padding documentation was judged as adequate in only 8 (18%). While some cases had partial, though inadequate notation, there was a *complete absence* of documentation of patient positioning in 24 (55%) of these claims, and the use of protective padding was *completely undocumented* in 25 (57%) of the claims in this data set.

Mechanisms of injury

In the American Society of Anesthesiologists (ASA) Closed Claims Database, 670 claims (16% of 4,183) were for anesthesia-related nerve injury. Investigators noted, “with the exception of spinal cord injury, the actual mechanism of injury was not apparent in the file of most claims for nerve injury.”⁴ The most common mechanisms of spinal cord injury included epidural hematoma, chemical injury, anterior spinal artery syndrome, and meningitis.

Contributory factors for ulnar nerve injuries identified by ASA investigators included perioperative trauma, axillary blocks, and lower body surgery accomplished with regional anesthesia and intravenous sedation. The ASA investigators noted that elbows were padded in 27% of the ulnar nerve injury claims in their database.

Regarding brachial plexus injuries, ASA researchers noted that 10% of brachial plexus injuries were “clearly related to patient position.”⁴ The positioning issues included use of shoulder braces or the head-down position, malposition of the arms, and sustained neck extension. Paresthesias were not universally present (at least they were not documented as having occurred) when regional blocks resulted in brachial plexus injuries.

The paucity of documentation related to patient positioning and use of protective padding in the AANAF Closed Malpractice Claims Database makes elucidation of causative factors difficult and, at best, speculative. In 32 (73%) of the AANAF nerve injury cases, documentation of patient positioning was judged as inadequate; descriptions of protective padding were inadequate in 36 (82%) of the cases reviewed. Some general principles of physiology and practice provide an understanding of how perioperative nerve injury occurs.

Pressure applied to a body surface over time can injure soft tissue, nerves, and vasculature. Small pressure gradients are responsible for the movement of substances at the microcapillary level. Cellular perfusion results from differences in tissue, hydrostatic, and colloid osmotic pressures. Combined arterial capillary and interstitial fluid pressures of 41 mm Hg are opposed by a colloid osmotic pressure gradient of 28 mm Hg. The resulting 13-mm-Hg pressure difference causes flow out of the capillary into the cells. Arterial capillary inflow may be opposed by externally applied pressure, resulting in ischemia.^{5,6}

External pressure may limit venous capillary outflow, causing an increase in venous capillary pressure and a decrease in the tissue-capillary pressure gradient. Tissue edema develops as fluid is sequestered in the cells and interstitial space. The arterial-venous pressure gradient is reduced, and this reduction decreases tissue perfusion along the capillary. If venous and tissue pressures continue to rise, arterial inflow eventually is blocked and ischemia results.^{5,6}

The underlying cause of all tissue damage is inadequate perfusion. Ischemia may be due to occlusion of major vascular structures or restricted capillary perfusion. Metabolism continues despite inadequate perfusion, and tissue acidosis ensues, with failure of membrane pumps. As a result, sodium ions accumulate

intracellularly, water moves into the cells, and intracellular volume increases. Tissue edema results and contributes to ischemia by increasing tissue pressures and preventing the movement of fluid and nutrients from the capillaries into the cells.^{5,6}

Standard VI of the AANA Scope and Standards for Nurse Anesthesia Practice reads: “There shall be complete, accurate, and timely documentation of pertinent information on the patient’s medical record. Interpretation: Document all anesthetic interventions and patient responses. Accurate documentation facilitates comprehensive patient care, provides information for retrospective review and research data, and establishes a medical-legal record.”⁷

Recommendations to prevent nerve injury

- It is imperative to thoroughly conduct and document all aspects of the preoperative evaluation. Included should be a complete patient health and anesthetic history, identification of all factors placing patients at high risk for neurological injury, establishment of ASA physical status classification, and a thorough physical assessment.¹⁻³ In the present study, 17 (39%) of the claims had inadequate or missing documentation of preinduction activities. Furthermore, 31 (70%) of the patients in the claims involved ASA status of II or more. By obtaining a complete preanesthetic history, specific high-risk areas such as preexisting neuropathies (eg, diabetes mellitus, carpal tunnel syndrome, radiculopathy) can be identified and evaluated more extensively.

- Identify factors that influence the development of neurological injury (Table 2):²

1. *Positioning devices:* Straps and other ancillary positioning devices may cause nerve compression and nerve injury if tightened excessively. Stirrups, used for the lithotomy position, are of particular concern if used improperly. If the practitioner is not knowledgeable about correct positioning of the lower extremities when using these devices, a devastating injury may occur due to excessive pressure to the common peroneal nerve. Some devices such as bolsters, used to stabilize extremities to maintain a specific position, may induce a compartment syndrome that can result in compression injury.^{2,3} There are many ancillary positioning devices (eg, axillary rolls, shoulder braces, straps) that fall into this category, and providers should remain cognizant of the potential for injury resulting from the use of such devices.

2. *Length of procedure:* The risk and severity of neurological injury is associated with the length of the procedure. When combined with stretching or compression of a nerve, the potential for injury is exacerbated.

Table 2. Risk factors for positioning injuries

Positioning devices
Table straps
Leg holders
Axillary roll
Bolsters (eg, "bean bag")
Fracture table post
Shoulder braces
Positioning frames
Headrests
Length of procedure
Exceeding 2 hours' duration
Body Habitus
Obesity
Extremely underweight
Bulky musculature
Malnutrition
Preexisting Pathology
Low-flow states
Hepatic disease
Diabetes mellitus
Peripheral neuropathies
Alcohol or tobacco use
Limited joint mobility
Anesthesia technique
Regional anesthesia
Hypotensive technique
General anesthesia

bated for procedures of increasing duration.² Of the cases included in the AANAF Closed Malpractice Claims Database, 57% (25) of the injuries reported occurred during procedures exceeding 2 hours' duration. Therefore, a high degree of vigilance should be maintained throughout the intraoperative period since the time frame is so ill defined.

3. *Body habitus*: People with abnormal nutritional status are at increased risk for nerve injury intraoperatively secondary to surgical positioning.² Body habitus may be assessed by deriving BMI and ideal body weight. The BMI is calculated as follows: BMI = weight/height.⁸ (The weight is given in kilograms and the height in square meters.) Extremely underweight people (BMI ≤ 21 kg/m²) and obese people (BMI > 28 kg/m² or those whose actual body weight is 20% greater than ideal body weight) are susceptible to nerve injury secondary to compression and hypoperfusion of the nerve.^{2,4} In the present study, we arbitrarily selected a reference range of 21 to 30 kg/m² as normal body habitus. The lower limit of 21 kg/m² was determined based on our conservative opinion that ideal body weight falls within a BMI range of 20 to 25 kg/m². The upper limit was determined on our conservative opinion of obese people having a BMI of 30 kg/m² or more.^{2,8} As a result, 16 cases (36%) reviewed

fell out of the range of normality. If obesity was noted on the record as a preexisting health condition by the anesthesia provider, but the BMI could not be calculated due to absence of patient height and weight in the record, the patient was included in these 16 cases. In this database, 13 (30%) of 44 cases had insufficient documentation to ascertain body habitus. We treated this recognized limitation of retrospective databases (ie, missing data) in the most conservative manner.

4. *Preexisting pathophysiology*: Many pathophysiological conditions exacerbate the risk for nerve injury due to surgical positioning. Low blood flow states such as arterial or venous insufficiency, cardiac insufficiency, shock, and hypertension or hypotension are common examples. Diabetes mellitus is another important risk factor due to preexisting peripheral neuropathies and vascular insufficiency. The excessive use of tobacco and alcohol also may contribute to nerve injury due to the well-appreciated effects of impaired oxygen-carrying capacity, malnutrition, and impaired sensorium. In the present study, 24 (55%) of the patients had preexisting pathological conditions that placed them at increased risk for nerve injury. When abnormal body habitus was included as a preexisting condition, the percentage of patients with risk factors increased to 70% (n = 31).

5. *Anesthetic techniques*: The risk of nerve injury resulting from patient positioning increases with general anesthesia.² In the present study, 29 (66%) of the patients received a general anesthetic. A possible explanation describing the observed phenomenon is the inability of patients to verbalize or move in response to discomfort or pain. In addition, the use of certain anesthetics such as muscle relaxants and volatile anesthetics can result in excessive joint mobility during surgical positioning.³ Other factors, such as hypotension (deliberate or inadvertent) and Trendelenberg positioning, decrease perfusion pressures to extremities, necessitating constant vigilance to prevent injury.

- Advancing age and male sex have been implicated as risk factors.^{3,4} In the AANAF database, there was an equal distribution of nerve injuries reported in both males and females. It is important to recognize that the database may not be a representative sample of practice at large; herein the predominant age range was 20 to 60 years, with only 7 (16%) of 44 older than 60 years. In this study, neither sex nor advancing age seemed to place a patient at higher risk for nerve injury.

- Refrain from placing patients in positions that will anatomically change the orientation of the nerve, causing stretching or compression injuries. Perform a final check before surgical draping. Positions known to predispose to peripheral nerve injury include arm

abduction of more than 90°, shoulder girdle compression, pronation of arms, lateral rotation of the shoulder in combination with shoulder abduction, contralateral neck flexion, full elbow extension, compression of ulnar nerve by the table edge when tucking arms at the sides, and wrist extension.^{3,9} Vigilance should be maintained when tucking arms, and adequate padding should be used to prevent ulnar nerve compression injuries, the primary postoperative peripheral neuropathy found in the study completed by Cheney et al.⁴ Effective padding can be obtained, such as foam egg crate, blankets, and towels. Padding may help protect against direct compression due to surgeons leaning on the patient. Neutral positioning should be maintained at all times to decrease the risk of stretch injury, and all pressure points should be padded adequately to prevent nerve compression. A high index of suspicion on the part of the anesthesia provider is essential to drive behaviors oriented toward preventing nerve injury. Of the cases reviewed, improper patient positioning was determined to be the mechanism of injury in 16 (36%).

- Regional anesthesia sometimes is implemented *after* induction of anesthesia for postoperative pain relief. Extreme caution should be used during these procedures because regional anesthesia administered to patients already under general anesthesia can be hazardous. An increased risk of perioperative neurologic complications exists since the patients are unable to respond to painful stimuli secondary to intraneural injection, direct needle trauma, or elicited paresthesias. Prospective studies have not been conducted to support these concerns, but individual cases are reported. However, research implicates direct trauma and toxic effects in the complications resulting from needle placement or injection of local anesthetics.¹⁰

- A nerve stimulator should be used during peripheral nerve localization. It allows for exact needle location without eliciting paresthesia. Fanelli et al¹¹ experienced a 94% success rate when using a nerve stimulator, and smaller volumes of local anesthetic were required than those usually reported during placement of peripheral nerve blocks due to ensuring a closer proximity of the drug to the nerve. Although the use of a nerve stimulator will not solely eradicate the potential of causing peripheral nerve injury, it can increase the success rate of regional blockade without increasing the risk of neural injury. Clinicians must remain aware of the unchanged risk of intraneural injection while using a nerve stimulator. Intraneural injections of local anesthetic with added epinephrine or phenylephrine may increase the degree of neuronal damage secondary to axonal degeneration.¹² This same

study suggested that intraneural injection of plain local anesthetic solutions also caused neural injury; however, the extent of damage incurred may be less debilitating. The primary purpose of adding epinephrine to local anesthetics is to increase the duration of action and decrease the risk of systemic toxic effects; however, epinephrine is minimally effective for prolonging the duration of action in local anesthetics that are highly protein bound (eg, bupivacaine). Therefore, the necessity of adding epinephrine to local anesthetic infiltrations should be taken into consideration to avoid the risk of profound neural injury.

- Pneumatic tourniquet pressures of more than 400 mm Hg are known to be associated with postoperative nerve injury.¹¹ Only the minimally effective pressure should be used for occluding blood flow to the extremity. General guidelines suggest using tourniquet pressures no greater than 2 times the systolic pressure for the lower extremity and 70 to 90 mm Hg greater than the systolic pressure for the upper extremity. In addition, because tourniquet time is an independent risk factor, tourniquet times should be limited to less than 2 hours to decrease the risk of neural ischemia.¹³

- As observed in the present study, providers should recognize that anesthetic complications, specifically nerve injury, can manifest symptoms days into the postoperative period and do not end with the termination of the anesthetic.

- Exact and concise documentation is absolutely essential in anesthesia care–related record keeping. In more than 50% (>22) of the cases, adequate documentation was lacking for positioning *and* the use of padding. In a recent, national, multihospital study, documentation of anesthesia care was globally deficient, with patient positioning information particularly lacking.¹⁴ Ultimately, the requirement of documentation drives provider monitoring and behaviors and identifies whether standards of anesthetic care have been met. For example, if patient positioning is required to be checked and recorded at frequent intervals (as are vital signs per standard of care), anesthesia providers will be prompted to adhere to those guidelines and, we hope, recognize and rectify precarious positions before peripheral nerve damage occurs.

- Although the occurrence of nerve injury cannot be prevented absolutely, knowledge of the risks and mechanisms of nerve injury with implementation of preventive strategies may decrease the occurrence. With all standards of care being met and documented, it is less likely for liability for patient injury to reside with the provider. The anesthesia provider was found liable for patient injury in 19 (43%) of 44 cases. Of

those 19 cases, inadequate patient positioning was deemed to be the cause in 10 of them (53%). Of the remaining 9 cases, there was a high likelihood that positioning was a primary factor in the mechanism of injury in 2 cases. In addition, 5 of the injuries were due to neuraxial blockade (hematoma formation and catheter migration) or lack of vigilance (including that of noninvasive blood pressure cuff use). In the 2 cases not accounted for, the cause of the injury could not be determined.

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