CONTINUING EDUCATION

The Prevention and Recognition of Ulnar Nerve and Brachial Plexus Injuries

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Perioperative peripheral nerve injury is a serious yet preventable perioperative complication. Since the inception of the American Association of Anesthesiologists Closed Claim Project, the incidence of peripheral nerve injury has remained constant with an overall reported prevalence rate of 15% to 16%. To date, the most frequent nerve injuries are ulnar nerve neuropathy and brachial plexus injury. This article will review the clinical presentation, pathophysiology, causative and risks factors, and preventive measures for the two most common nerve injuries. Knowledge of the anatomical structures and components of peripheral nerves prone to injuries during surgery can assist in defining precautionary actions in the perioperative setting. Positioning techniques in the operating room, early recognition of neuropathies, and use of a perioperative tool in the postoperative setting are keys to reduce significant clinical complications.

Keywords: *perioperative peripheral nerve injury, ulnar nerve, brachial plexus, positioning.*

OBJECTIVES—1. IDENTIFY NERVE structures; 2. discuss the Sunderland's system of classification for grading nerve injury; 3. describe risk factors for nerve injury, and; 4. discuss postoperative assessment and diagnosis strategies.

The optimal patient position during a procedure affords the surgeon maximum visibility and access while minimizing the patient's physiological stress. Even when great care is taken, however, positioning injuries may occur. In 1990, insurance data showed that 15% of closed medical claims continue to include perioperative peripheral nerve injuries (PPNI), with 57% involving the brachial plexus or ulnar nerves.[1] The most recent analysis of American Society of Anesthesiologists (ASA) Closed Claims Project in 1999 reported a 16% incidence rate of PPNI.[2,3] The ASA Closed Claim Project is an initiative that identifies etiology and causes of anesthesia-related injuries to improve patient safety.[4]

The prevention of PPNI requires an interdisciplinary approach among health care providers in the perioperative setting. Certain roles are delineated to individual members of the perioperative team, starting in the preoperative setting until the postoperative setting. The preoperative nurses' knowledge of risks factors and use of preoperative assessment tools is critical to detecting high-risk patients. The surgeon plays a role in determining the length of surgical time, type of surgical procedures, and position of the patient. On the other hand, the circulating registered nurse and the anesthesia provider can collaborate in the use of positioning devices, protective pads, and positioning strategies, while frequently monitoring patient's hemodynamic status during surgery. In addition, a focused perioperative history and physical assessment may detect preexisting conditions linked to nerve injury. Furthermore,

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the postanesthesia care unit nurses' knowledge on early identification of signs of nerve injury reduces further damage and neurological consequence.

Due to the complex nature of PPNI, only two nerve injuries are discussed in this article. This article presents an overview of ulnar nerve neuropathy and brachial plexus injuries, including their classification, causative factors, and clinical presentations. After the review of the literature, a perioperative tool is presented to guide in the prevention and recognition of the two most common PPNI in the perioperative setting.

Review of the Literature

Automatic and manual searches of major databases were the chief methods used to examine the evidence. Databases included PubMed, MEDLINE, Cumulative Index to Nursing and Allied Health Literature, and the Cochrane Library. The electronic search strategy included the following MeSH and text terms: perioperative nerve injury, peripheral nerve injury, ulnar nerve injury, brachial plexus injury, and positioning with the use of appropriate Boolean modifiers. The search was limited to full-text English language articles.

Peripheral Nerve Anatomy and Levels of Nerve Injury

There are many reasons peripheral nerves are damaged or injured in the perioperative phase. Surgical patients exhibit reduced muscle tone and decreased resistance to positioning that can lead to nerve tissue injury under anesthesia.[4] The proposed mechanism of PPNI is not completely understood. Current literature offers three major pathophysiologic conditions that predispose the patient to injury. It has been documented that perioperative peripheral neuropathies are a result of a stretch, compression, or ischemia.[5,6] These injuries are exhibited on a continuum of severity and vary in their prognosis. Stretching involves minor disruption of intraneural blood vessels, and can lead to tearing of the intraneural connective tissue with increased severity of stretch.[7] Prolonged stretching, especially during general endotracheal anesthesia, causes interruption of the nerves' vascular supply. Compression or excessive pressure may result in decreased neuronal conduction and lead to demyelination when intraneural edema accompanies the escalating severity of the compression. In surgery, compression can occur as a consequence of the pressure of the nerve against a bony prominence or a hard surface such as the arm board and the operating table. Overall, the common component of PPNI is decreased capillary perfusion, which ultimately leads to ischemia.

Another possible mechanism of PPNI is explained in the phenomenon of the double crush syndrome.[8] The phenomenon, postulated by Upton and McComas,[9] describes a multilevel injury to the peripheral nerve, which suggests that a proximal injury renders the distal section of the nerve more vulnerable to damage. Therefore, the overall effect is a permanent nerve injury.

In general, peripheral nerves consist of several axon bundles or fascicles. These nerves are covered with connective tissue layers called epineurium, perineurium, and endoneurium (Figure 1).[10,11] The epineurium is the outermost connective tissue layer that contains all the nerve fibers comprising the nerve. The perineurium surrounds bundles of nerve axons in fascicles, and the endoneurium encases each myelinated fiber. Peripheral nerves have a single Schwann cell myelinating each axon individually within the endoneurium layer.[12,13]

In 1943, Sir Herbert Seddon developed a classification system for nerve injuries based on tissue injury and correlated with the prognosis for recovery.[14] Seddon classified nerve injuries on a three-tiered system from least to greatest extent of injury: neurapraxia, axonotmesis, and neurotmesis (Figure 2).[15] Later, Sunderland updated the classifications and included subcategories when the endometrium is involved (Table 1).[16]

The first tier of an injury is neurapraxia (grade I), in which the anatomical features of the nerve remain intact but with impaired nerve conduction. The myelin is involved and results in loss of motor function with paralysis. Recovery time is expected within weeks to months. Next is axonotmesis (grade II), whereby the myelin and axon injury leads to separation of the axon from the cell body distal to the injury, a result of ceasing metabolic support. This mechanism of injury is referred to as Wallerian degeneration. The prognosis of this