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Preventing Upper Extremity Perioperative Nerve Injury: Myth or Reality?

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ABSTRACT

Perioperative peripheral nerve injury (PPNI) is a rare complication that can lead to significant patient disability. PPNI is a substantial cause of medical malpractice claims for anesthesiologists. The etiology of nerve injury is poorly understood making prevention of this complication a challenge. PPNI had been reported despite appropriate padding and positioning practices. Upper extremity nerve injury is the most common form of PPNI encountered in clinical practice and in reviews of closed malpractice claims. In this article, we briefly review the mechanisms of upper extremity PPNI and discuss considerations that may reduce the likelihood of its occurrence.

INTRODUCTION

Perioperative peripheral nerve injury (PPNI) is an uncommon complication that can lead to significant patient disability and anesthesiology malpractice claims. The reported incidence of PPNI is 0.03% to 0.1% [1,2]. Upper extremity PPNI comprises 55%-58% of all nerve injury cases [1,3]. PPNI is the second most common cause of anesthesia malpractice claims after death [3]. Despite multiple human, cadaveric and animal research models, we do not have a clear understanding of the exact mechanism of PPNI [4]. This is primarily because the etiology is multifactorial involving patient predisposition and a variety of precipitating factors that include intraoperative patient positioning, physiological parameters, surgery related factors and postoperative positioning. PPNI often occurs without an identifiable cause and despite applying standard preventive measures like proper positioning and padding. The American Society of Anesthesiologists (ASA) publishes a practice advisory for the prevention of perioperative peripheral neuropathies [5]. In this article, we will briefly review the mechanisms of upper extremity PPNI and list considerations to reduce intraoperative upper extremity peripheral nerve ischemia.

REVIEW

The mechanisms of PPNI include compression, stretch and inflammation leading to a reduced perfusion pressure in the nerve fibers [6]. Intraneural hypoperfusion and ischemia is the common final pathway of the various insults leading to PPNI [7]. Stretching of a peripheral nerve by 5% or more can collapse intraneural capillaries leading to an increase in the intraneural pressure, a reduction in nerve perfusion pressure and subsequent ischemia [8]. Compression can lead to increased local tissue pressure, decreased perfusion pressure and subsequent nerve fiber ischemia [9]. More recently inflammatory and autoimmune mechanisms have been identified as causes for PPNI. [10-12]. Nerve biopsies in these cases showed ischemic and inflammatory injuries to the micro vessel wall and axonal degeneration. Many of these cases were treated with anti-inflammatory medication with a favorable clinical response. This type of PPNI, which develops without an identifiable cause and improves with immunotherapy, is described as postsurgical inflammatory neuropathy [11].

The ulnar nerve is anatomically susceptible to compression at the ulnar grove [13]. Men are more susceptible to ulnar neuropathy than women are because they have relatively less fat content in the medial aspect of the elbow. Ulnar nerve is susceptible to stretch with higher degrees of elbow flexion. Risk factors for perioperative ulnar neuropathy include male gender, extreme body habitus and prolonged hospitalization [14].

The brachial plexus has a superficial location and passes through two fixed points of anatomy, the intervertebral foramen and the axillary sheath, making it at risk for stretch

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and compression during surgery. Stretch can occur when the arm is abducted to >90°, with the application of sternal retraction during cardiac surgery, or due to lateral head rotation away from the plexus. Compression of the nerves between the clavicle and the first rib can also occur due to the use of shoulder braces in the steep head-down position [15].

The median nerve courses through the carpal tunnel, making it susceptible to compression with minimal swelling. However, stretch is the main mechanism of perioperative median nerve injury. Median neuropathy commonly occurs in men between the ages of 20-40 years of age [16]. Men with bulky and well-developed biceps have reduced flexibility and an inability to fully extend the elbow. During general anesthesia, with a relaxed biceps muscle, the elbow can be stretched to an extent, which is more than in the awake state, making the median nerve susceptible to stretching, ischemia and injury [16].

Compression at the spiral groove is the main mechanism of perioperative radial injury [18]. It may occur due to compression of the radial nerve by vertical bars of abdominal retractors in the supine arms out position. In the lateral decubitus position, the vertical bars supporting the overhead arm board may compress the dependent radial nerve at the radial groove while the non-dependent radial nerve may be compressed by the edge of the overhead arm board if it protrudes into the mid humerus. Also, the radial nerve may be compressed when the arm loses support, slips and the weight of the upper extremity is supported against the edge of the arm board or operating room table at mid hummers.

DISCUSSION

Identification of high-risk patients, optimizing upper extremity position to minimize peripheral nerve stretch and compression, maintaining physiologic parameters and early identification of conduction changes are the underpinning principles of all measures to minimize the occurrence of PPNI.

The following are considerations to reduce the occurrence of intraoperative upper extremity nerve ischemia and possibly injury:

- Perform preoperative evaluation to identify risk factors. Determine whether the patient can comfortably tolerate the anticipated operative position
- Limit arm abduction in a supine patient to 90°
- In the supine operative position, maintain the forearm in supination or the neutral positions. Avoid forearm pronation
- Avoid excessive flexion of the elbow
- Avoid excessive extension of the wrist
- Avoid pressure on the spiral groove of the humerus by metal bars, operating table edge, or the edge of armrest padding if it is higher than the level of the operating table padding
- Extend the elbow to the point that was comfortable during preoperative evaluation
- Perform periodic perioperative assessments of intraoperative positioning
- Apply padding to the arm board and the elbow. Avoid tight safety straps
- Apply a chest roll in the lateral decubitus position. Avoid placing the roll in the axilla
- Avoid the use of shoulder braces in the steep head-down position
- Perform a simple postoperative assessment of extremity nerve function for early recognition of peripheral neuropathies
- Document specific perioperative positioning details
- When available, use neuromonitoring techniques such as somatosensory evoked potential (SSEP) to identify intraoperative upper extremity conduction changes. Although intraoperative conduction changes many not necessary translate to PPNI, reversing intraoperative nerve conduction changes is prudent and may help reduce PPNI [17]. Intraoperative use of SSEP to optimize the arm position and the maintenance of intraoperative MAP above 80 mm Hg while avoiding MAP below 55 mm Hg can significantly reduce the incidence of abnormal intraoperative conduction changes [17,18].

CONCLUSION

Preventing a multifactorial perioperative complication such as PPNI remains a challenge for the perioperative team. While the scientific community had made honorable strides to advance the knowledge of PPNI, we do not have the complete understanding of PPNI to be able to prevent it. However, we have enough knowledge to make the attempt at avoiding it a reality.

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