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Review Article

Types of intraoperative positioning nerve injuries

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ABSTRACT

Intraoperative positioning nerve injuries are a known complication that can occur during surgical procedures when patients are placed in specific positions on the operating table. The causes of intraoperative positioning nerve injuries are multifactorial and are associated with aspects related to how the patient is positioned during the surgical procedure and the duration for which pressure or tension is applied to nerves. This study was conducted to identify and categorize the various types of intraoperative positioning nerve injuries and to establish prognostic classifications for these injuries. The aim was to address the imperative need for strategies to prevent and manage such injuries effectively. The study involved an extensive review of existing literature, encompassing databases such as PubMed, Web of Science, and Cochrane. Intraoperative positioning nerve injuries can be categorized based on several parameters, including the nature of the injury, the specific nerve or nerve plexus affected, and the severity of the damage incurred. Two major classification systems based on injury extent are Seddon's and Sunderland's classifications. Types based on anatomical region can be loosely divided into nerves present in the upper limb, lower limb, head and neck, and thoracic region. The prevention of intraoperative positioning nerve injuries is of paramount importance and hinges on meticulous preoperative planning, the utilization of appropriate positioning techniques, and the diligent monitoring of patients throughout the surgery.

Keywords: Nerve injury, Surgical procedures, Intraoperative positioning

INTRODUCTION

Iatrogenic nerve injuries are injuries attributed to trauma, induced during or after a surgical procedure. They can be a result of direct surgical damage, compression stress on a nerve due to incorrect positioning of the patient, or the introduction of neurotoxic substances during the operative procedure.[1] Iatrogenic nerve injuries have various types. Administration of nerve blocks or injections near the nerve can cause perforation or neurotoxicity. Another type of nerve damage can occur due to certain medical devices, such as catheters, pacemakers, or intravascular devices.

These devices can potentially cause nerve injury if they are not properly placed or if they migrate within the body.[2] The most common type of iatrogenic nerve injury is a surgical nerve injury. These injuries can result from direct nerve damage during the surgical procedure, such as perforation or slicing, or during surgery when the patient's positioning or restraints lead to nerve compression or stretching. The latter is known as an intraoperative positioning nerve injury.[2]

Intraoperative positioning nerve injuries occur during a surgical procedure due to the patient's position on the operating table. These injuries typically result from pressure, compression, or stretching of nerves while the patient is under anesthesia and in a fixed surgical position.[3] These nerve injuries can range from temporary numbness, weakness, and tingling to more severe, long-lasting damage, such as complete and permanent loss of sensation, depending on the extent and duration of the nerve compression or stretching.[4] These injuries can happen in various surgical settings and may involve different nerves, depending on the surgical procedure and the patient's positioning. The etiology of intraoperative positioning nerve injuries involves various factors related to the patient's positioning during surgery and the duration of pressure or tension applied to nerves.[5] Poor positioning, a lack of padding during the surgery, and incorrect placement of tourniquets can contribute to nerve injury.[6] In addition to these probable causes, an intraoperative nerve injury has been associated with prolonged hospital stays and comorbidities such as diabetes mellitus, hypertension, and tobacco use.[6] The symptomatic presence of intraoperative nerve injury may be delayed and can present 48 hours after the surgical procedure, causing doubt about the actual cause of the injury.[7]

The overall prevalence and incidence of intraoperative positioning nerve injury were difficult to extract from the literature due to the heterogeneity of the available evidence. However, incidences of ulnar injury Brachial plexus injury and lower limb injury are accessible. Retrospective and prospective studies from the Mayo Clinic showed that the incidence of intraoperative injury to the ulnar nerve was 0.04% and 0.52%, respectively.[8,9] In addition to that, similar incidence levels (0.2–0.6%) were recorded for brachial plexus injury in another study.[7] The incidence of intraoperative positioning nerve injuries can range from rare to relatively common, depending on the surgical context. Some surgeries are associated with a higher risk of these injuries than others. For certain surgical procedures, such as those involving the extremities or the head and neck, there may be a higher likelihood of nerve injuries due to the challenging positioning requirements.[7] Additionally, the presence of underlying medical conditions, anatomical variations, and patient-specific factors can also influence the risk of intraoperative positioning nerve injuries. Longer surgical durations, more complex procedures, and the use of muscle relaxants also increase the likelihood of these injuries.[6] Some patients may not report or recognize mild or transient nerve injuries, leading to underreporting and potentially underestimated prevalence rates. These injuries may be underreported in the literature because they are often considered preventable and may not result in long-term disability. This study was done to identify the different types of intraoperative positioning nerve injuries and their prognostic classifications and to cater to the need for the prevention and management of these injuries.

METHODS

Based on a thorough assessment of the literature that began on 06 September 2023, and used databases like PubMed, Web of Science, and Cochrane, this study was conducted. Throughout the process, a variety of medical terminologies and their probable combinations were used. Google Scholar was also used to do a manual search for relevant research terms. The focus of the literature search for this study was on the burden, pathogenesis, predisposing factors, types of iatrogenic nerve injuries, burden, prevention, and therapy of intraoperative positioning nerve injuries. The selection of articles was based on multiple factors, and not just one.

DISCUSSION

Intraoperative positioning nerve injuries are prevalent but underreported for a variety of reasons, including the ephemeral nature of the injuries, insufficient documentation by healthcare providers, and a general lack of knowledge. To address underreporting of these injuries and improve patient safety, healthcare institutions and surgical teams can begin by referring to a standard or proper classification system for the injury, so that reporting can be made efficient, ultimately resulting in less underreporting of intraoperative positioning nerve injuries and improved patient safety. Intraoperative positioning nerve injuries can be classified based on various factors, including the type of injury, affected nerve or plexus, and severity of the damages.

Classification 1 – type and severity of nerve injury

The most widely accepted classification for nerve injuries is either by Seddon or Sunderland.[10,11] Both these classification systems are relatively similar; however, Sunderland's classification is graded and more detailed as compared to Seddon's, which is three-tiered categorizing nerve injuries into three main types based on their severity and characteristics.

Seddon's classification

Seddon's classification provides a valuable framework for assessing and categorizing peripheral nerve injuries based on their severity and characteristics. The classification underscores the importance of early intervention in cases of severe nerve injuries, such as neurotmesis, to optimize functional recovery and outcomes. Seddon's classification divides peripheral nerve injuries into three main

categories, each representing a different level of injury severity, illustrated in Figure 1.

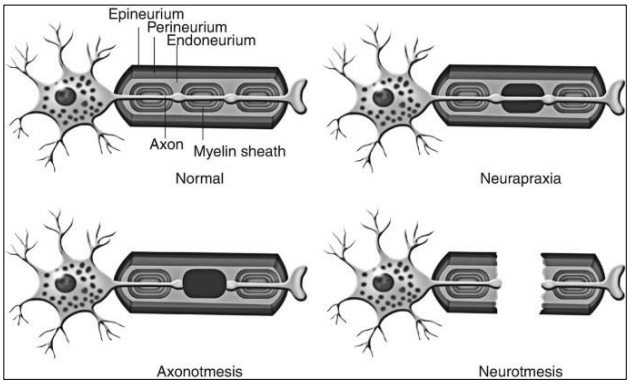

Figure 1: Seddon's classification of nerve injury.[29]

Neuropraxia

Neuropraxia is the mildest form of nerve injury, characterized by a temporary loss of nerve function without structural damage to the nerve.[10,12] The nerves are usually unharmed, and the injury is reversible. Possible causes include nerve compression or stretching during muscle positioning. Because there is no axonal damage, recovery should take only a few weeks.[12]

Axonotmesis

Axonotmesis is a more severe nerve injury that involves the disruption of axons (nerve fibers) within the nerve, but the nerve's structural framework remains intact.[10,13] The axons are disrupted, resulting in Wallerian degeneration distal to the injury; however, the nerve's structural connective tissue components, such as the endoneurium, perineurium, and epineurium, are preserved. It is well known that recovery is incomplete, resulting in varying degrees of sensory and motor deficits.[13]

Neurotmesis

Neurotmesis is the most severe type of peripheral nerve injury, involving complete nerve disruption or transection, resulting in a physical gap.[10,13] Neurotmesis is distinguished by complete avulsion or severity of the nerve, as well as disruption of the nerve's structural components, which include axons, endoneurium, perineurium, and epineurium. Surgical intervention is typically needed for nerve repair, with the extent and timing of the intervention determining the outcome.[13]

Sunderland's classification

Sunderland's classification categorizes peripheral nerve injuries into five grades, from mildest Grade 1 to most severe Grade 5. According to Sunderland, this classification system was proposed in response to the limitations identified by scholars in Seddon's classification. The new classification was thus based on the severity of the injury, and not just its causes.[11] This classification system assists healthcare professionals in determining the extent of nerve damage, predicting recovery potential, and choosing the best treatment approach, whether conservative management, nerve grafting, or surgical repair is required.[11] The relationship between Seddon's and Sunderland's classification is efficiently described in Figure 2.

Seddon	Sunderland	Pathophysiology
Neuropraxia (compression)	Type 1	Local myelin damage with the nerve still intact
Axonotmesis (crush)	Type 2	The continuity of axons is lost. The endoneurium, perineurium, and epineurium remain intact. Loss of continuity of axons with Wallerian degeneration due to disruption of axoplasmic flow
	Type 3	Type 2 with endoneurial injury
	Type 4	Type 2 with endoneurial and perineurial injury but an intact epineurium
Neurotmesis (transection)	Type 5	Complete physiological disruption of the entire nerve trunk. Early surgical intervention necessary. Prognosis guarded

Figure 2: Classification of nerve injury.[7]

Grade 1

Sunderland's system's first grade also refers to neuropraxia, a temporary loss of nerve function. In grade 1, the structural integrity of the nerve remains intact, axonal disruption is absent, and recovery is typically complete and spontaneous.[11]

Grade 2

The second grade of injury in this classification system is also like Seddon's, which is axonotmesis. It represents a more severe nerve injury, which involves the disruption of axons, however, the endoneurium is unharmed. Regeneration of axons can be anticipated but with a few sensory and motor insufficiency.[7,11]

Grade 3

Grade 3 injuries in Sunderland's classification are commonly termed endoneuria fibrosis.[11] Damage to the endoneurium is identified with subsequent fibrosis and scarring. In this stage, regeneration of axons is less likely and slower than in lower-grade injuries, and functional recovery may be poor, with residual sensory and motor deficits. Grade 3 injuries are typically seen in cases of severe crush injuries, traction injuries, or when there is delayed intervention.[11,13]

Grade 4

The fourth stage involves damage to the perineurium, the protective sheath surrounding bundles of axons, and hence known as perineurial fibrosis. Typical characteristics are severe disruption of axons and endoneuria fibrosis, and

damage to the perineurium, leading to fibrosis and scarring around individual fascicles. Regeneration of the nerve is deemed challenging and restoration of normal function may be insufficient.[11,13]

Grade 5

Neurotmesis is the most severe type of peripheral nerve injury, involving complete nerve transection or rupture. This stage is similar to the final stage of Seddon's classification, which is total nerve discontinuity, which almost always results in complete transection or avulsion.[11,13,14]

Classification 2 – affected nerve or plexus

Intraoperative positioning nerve injuries can occur at various anatomical sites depending on the surgical procedure and the patient's positioning on the operating table.[7,15] These injuries are often categorized based on the location of the affected nerve.[4] The anatomy of nerves affected during incorrect intraoperative positioning can be seen in Figure 3.

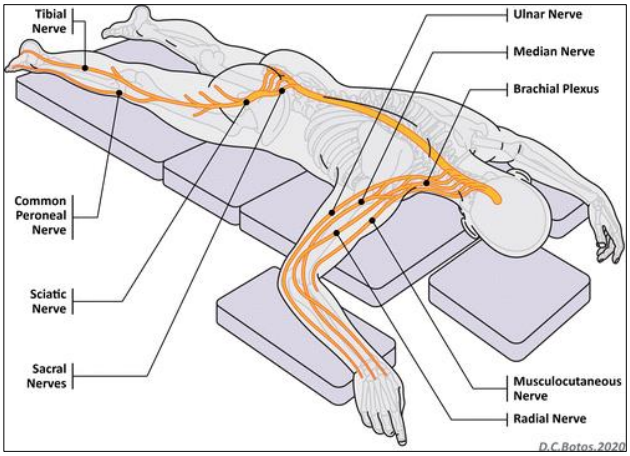

Figure 3: Intraoperative positioning and nerve anatomy.[30]

Upper limb nerve injuries

The brachial plexus, a complex network of nerves governing muscle movements and sensory perception in the shoulder, arm, and hand, is susceptible to injury when a patient's arm undergoes certain positions that either stretch or compress these nerves. Consequently, this can lead to various upper limb nerve injuries, including but not limited to radial nerve palsy, ulnar nerve damage, and median nerve impairment.[7] For instance, during surgical procedures involving the shoulder, such as those addressing shoulder issues, patients are often positioned in a supine posture with their arms abducted and externally rotated. Unfortunately, this positioning can exert stress on the brachial plexus, potentially resulting in nerve injuries.[15,16] One specific type of brachial plexus injury is radial nerve palsy, characterized by a weakening of the wrist and hand muscles, leading to the condition known as wrist drop.[17] Additionally, ulnar nerve compression may manifest during surgery, particularly when the patient's arm is flexed and abducted. This compression can induce discomfort and pain in the affected arm.[18] In essence, brachial plexus injuries are associated with certain surgical positions, particularly those involving the shoulder, and can encompass a range of nerve-related issues affecting upper limb functionality and sensation.[7,15]

Lower limb nerve injuries

Numerous nerves within the lower limb can face potential compromise during surgical procedures, leading to various forms of nerve injuries.[15] Among these, the peroneal nerve is a pivotal player, responsible for both muscle function and sensory perception in the lower leg and foot. In certain surgical scenarios, where the positioning of the legs places undue pressure or causes stretching of this nerve, peroneal nerve injuries may ensue. The consequences often manifest as a condition referred to as numbness experienced on the top of the foot.[7,16] In addition to the peroneal nerve, the femoral nerve takes center stage in the lower limb's neuromuscular dynamics. This nerve assumes responsibility for muscle function and sensation in the thigh and leg. Injuries affecting the femoral nerve typically occur during surgical procedures involving the hip or pelvis, where the nerve may be subjected to stretching or compression.[19,20] As a result, patients may experience pronounced weakness and encounter challenges in lifting the leg. Similarly, the sciatic nerve, a substantial nerve extending down the lower limb, is susceptible to injuries during surgeries focused on the pelvis or hip joint. The compression or stretching of the sciatic nerve can result in a spectrum of symptoms, including pain, numbness, and muscle weakness in the leg.[19,20] Furthermore, the lateral femoral cutaneous nerve, while less renowned than its counterparts, remains vulnerable during certain operative procedures. The compression or stretching of this nerve can bring about a condition known as meralgia paresthetica.[21] This condition is characterized by sensations of numbness and tingling primarily concentrated in the outer thigh and is commonly referred to as meralgia paresthetica.[21]

Head and neck nerve injuries

Injury to the facial nerve, which controls the muscles of the face has been observed and noted in the literature.[4] Such injuries can occur during head and neck surgeries when the patient's head is positioned in such a way that the facial nerve is compressed, resulting in facial weakness or paralysis.[4]

Trunk and torso nerve injuries

Intercostal nerves are located between the ribs and control sensation in the chest and abdomen. These nerves can be damaged during chest or abdomen surgeries, resulting in pain or sensory disturbances.[4] Lumbar and sacral nerves

are another example. These nerves emerge from the spinal cord and regulate lower limb function.[22] Spinal surgeries, for example, can result in nerve injuries and motor or sensory deficits involving the lumbar or sacral region.[22]

Other classifications

There are a few other classification systems mentioned in the literature for nerve lesions, however, they are not specific to the intraoperative positioning injuries. A classification of nerve lesions involving the brachial plexus (pre-surgical) was published in 2014.[23] Another classification differentiated between acute and chronic nerve lesions, specific for athletes.[24] Both classifications did not consider several factors affecting the nerve and the severity of the injury and hence, were deemed less accurate than the Sunderland classification. A few clinical symptom-based systems have also been proposed, considering impairments affecting the sensory, motor, or mixed function.[25,26] Regardless, the prognostic value of these classifications was not considered of value, since it lacked multiple factors and complexities of nerve injuries, specific to the intraoperative positioning.

Prevention and management

The prevention and management of intraoperative positioning nerve injuries are of paramount importance to ensure patient safety and optimize surgical outcomes. These injuries can lead to significant postoperative complications, including pain, weakness, and sensory deficits.

The American Society for anesthesiologists has designed a practice advisory for the prevention of perioperative peripheral neuropathies for the prevention of positioning nerve injuries.[27] A thorough evaluation of the patient's medical history, anatomy, and any preexisting neurological conditions that might increase the risk of nerve injuries is significant for the prevention of nerve injuries.[7] This assessment will inform the choice of surgical approach and positioning of the patient during the surgical procedure. In addition to that, appropriate use of patient positioning techniques that minimize nerve compression, stretching, or tension will aware the surgical team aware of the patient's body habitus.[15] Specialized padding and positioning aids are also available to reduce the risk of positioning injuries. Moreover, gentle handling of the patient’s limbs during the procedure is crucial to prevent nerve injuries. The surgical team can be trained in this regard, with a focus on awareness regarding intraoperative positioning nerve injuries.[28]

The management of intraoperative positioning nerve injuries starts with the removal of the stimuli causing the injury. Early recognition of the injury, repositioning, and thorough post-operative neurological assessment are a few ways through which the extent and severity of the injury can be minimized.[15] In cases of suspected or confirmed nerve injuries, consultations with neurologists or peripheral nerve specialists are significant to assess the extent of the injury and discuss potential treatment options.[28] Additionally, early rehabilitation and physical therapy maximizes the recovery potential.[28]

CONCLUSION

Intraoperative positioning nerve injuries are potential complications of surgical procedures that can lead to varying degrees of neurological impairment. These injuries can affect nerves in different anatomical regions, including the upper and lower limbs, head, neck, trunk, and spine. The severity of nerve injuries can range from mild neuropraxia to more severe axonotmesis and neurotmesis. Preventing intraoperative positioning nerve injuries is essential through meticulous preoperative planning, proper positioning techniques, and vigilant monitoring. However, if these injuries do occur, prompt recognition and appropriate management are vital to optimize patient outcomes and mitigate long-term complications. Collaboration among the surgical team, specialized consultation, and rehabilitation efforts play a pivotal role in achieving the best results for patients who experience such injuries.

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REFERENCES

1. Antoniadis G, Kretschmer T, Pedro MT, König RW, Heinen CP, Richter H-P. Iatrogenic nerve injuries: prevalence, diagnosis and treatment. Deutsches Ärzteblatt Int. 2014;111(16):273.
2. Lalkhen AG. Chapter 37 - Perioperative Peripheral Nerve Injuries Associated with Surgical Positioning. In: Tubbs RS, Rizk E, Shoja MM, Loukas M, Barbaro N, Spinner RJ, eds. Nerves and Nerve Injuries. San Diego: Academic Press. 2015:587-602.
3. Prielipp RC, Morell RC, Butterworth J. Ulnar nerve injury and perioperative arm positioning. Anesthesiology Clin North Am. 2002;20(3):589-603.
4. Winfree CJ, Kline DG. Intraoperative positioning nerve injuries. Surg Neurol. 2005;63(1):5-18.
5. Sawyer R, Richmond M, Hickey J, Jarrratt J. Peripheral nerve injuries associated with anaesthesia. Anaesthesia. 2000;55(10):980-91.
6. Welch MB, Brummett CM, Welch TD. Perioperative peripheral nerve injuries: a retrospective study of 380,680 cases during a 10-year period at a single institution. J Am Soc Anesthesiol. 2009;111(3):490-7.
7. Lalkhen AG, Bhatia K. Perioperative peripheral nerve injuries. Continuing Education in Anaesthesia Crit Care Pain. 2011;12(1):38-42.
8. Warner MA, Warner ME, Martin JT. Ulnar neuropathy. Incidence, outcome, and risk factors in sedated or anesthetized patients. Anesthesiology. 1994;81(6):1332-40.

9. Warner MA, Warner DO, Harper CM, Schroeder DR, Maxson PM. Ulnar neuropathy in medical patients. J Am Soc Anesthesiol. 2000;92(2):613.
10. Seddon H. Three types of nerve injury. Brain. 1943;66(4):237-88.
11. Sunderland S. A classification of peripheral nerve injuries producing loss of function. Brain. 1951;74(4):491-516.
12. Biso GMNR, Munakomi S. Neuroanatomy, neurapraxia. In: StatPearls. StatPearls Publishing. 2022.
13. Goubier J-N, Teboul F. Grading of nerve injuries. In: Nerves and nerve injuries. Elsevier. 2015:603-10.
14. Sonabend AM, Smith P, Huang JH, Winfree C. Chapter 195 - Peripheral Nerve Injury. In: Quiñones-Hinojosa A, ed. Schmidek and Sweet Operative Neurosurgical Techniques (Sixth Edition). Philadelphia: W.B. Saunders. 2012:2225-38.
15. Chui J, Murkin JM, Posner KL, Domino KB. Perioperative Peripheral Nerve Injury After General Anesthesia: A Qualitative Systematic Review. Anesth Anal. 2018;127(1):134-43.
16. Hewson D, Bedforth N, Hardman J. Peripheral nerve injury arising in anaesthesia practice. Anaesthesia. 2018;73:51-60.
17. Barner KC, Landau ME, Campbell WW. A review of perioperative nerve injury to the upper extremities. J Clin Neuromuscular Dis. 2003;4(3):117-23.
18. Chung I, Glow JA, Dimopoulos V. Upper-limb somatosensory evoked potential monitoring in lumbosacral spine surgery: a prognostic marker for position-related ulnar nerve injury. Spine J. 2009;9(4):287-95.
19. Barnett JC, Hurd WW, Rogers RM, Williams NL, Shapiro SA. Laparoscopic positioning and nerve injuries. J Minim Invasive Gynecol. 2007;14(5):664-72.
20. Dillavou ED, Roderick Anderson L, Bernert RA. Lower extremity iatrogenic nerve injury due to compression during intraabdominal surgery. Am J Surg. 1997;173(6):504-8.
21. Solomons JNT, Sagir A, Yazdi C. Meralgia Paresthetica. Current Pain and Headache Reports. 2022;26(7):525-31.
22. Barner KC, Landau ME, Campbell WW. A Review of Perioperative Nerve Injury to the Lower Extremities: Part I. J Clin Neuromusc Dis. 2002;4(2):95-9.
23. Yang J, Qin B, Fu G. Modified pathological classification of brachial plexus root injury and its MR imaging characteristics. J Reconstructive Microsurg. 2013;171-8.
24. Lorei MP, Hershman EB. Peripheral nerve injuries in athletes: treatment and prevention. Sports Med. 1993;16:130-47.
25. Giannini F, Cioni R, Mondelli M. A new clinical scale of carpal tunnel syndrome: validation of the measurement and clinical-neurophysiological assessment. Clinical Neurophysiol. 2002;113(1):71-7.
26. Goldberg BJ, Light TR, Blair SJ. Ulnar neuropathy at the elbow: results of medial epicondylectomy. J Hand Surg. 1989;14(2):182-8.
27. 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. Anesthesiology. 2011;114(4):741-54.
28. Kumar A, Shukla D, Bhat DI, Devi BI. Iatrogenic peripheral nerve injuries. Neurol India. 2019;67(7):135.
29. Martins RS, Siqueira MG. Peripheral Nerve Surgery. In: Joaquim AF, Ghizoni E, Tedeschi H, Ferreira MAT, eds. Fundamentals of Neurosurgery: A Guide for Clinicians and Medical Students. Cham: Springer International Publishing. 2019;201-9.
30. Fernandez CE, Franz CK, Ko JH, Walter JM, Koralnik IJ, Ahlawat S, et al. Imaging review of peripheral nerve injuries in patients with COVID-19. Radiology. 2021;298(3):E117-30.

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