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# Management of anesthesia for surgery in prone position for a patient with hereditary neuropathy with liability to pressure palsies. A case report and narrative literature review

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**Abstract:** The reported case describes a patient with hereditary neuropathy with liability to pressure palsies (HNPP) requiring a neurosurgical laminotomy procedure for an arachnoid cyst with medullary compression. HNPP is a rare pathology requiring meticulous anesthetic and surgical management. We give a detailed overview of the planning, simulation, and performance of the anesthesia procedure in order to minimize all potential risk factors for perioperative nerve injury. During the preparation of this case, where the positioning was extremely challenging, we reviewed the available literature for guidance. A few papers report the use of neuraxial anesthesia in patients previously diagnosed with HNPP. No reports could be found on the management of general anesthesia and positioning for major surgery in those patients.

**Keywords:** Hereditary neuropathy with liability to pressure palsies (HNPP); hereditary motor and sensory neuropathy; peripheral myelin protein 22 gene deletion (PMP22); intraoperative nerve injury; prone position; intraoperative care.

## Introduction

Hereditary neuropathy with liability to pressure palsies (HNPP) is a disorder characterized by recurrent sensorimotor nerve palsies elicited by pressure and stretch. This pathology requires meticulous anesthetic and surgical management to prevent intraoperative nerve injury during general as well as regional anesthesia.

The reported global incidence of perioperative nerve injuries, both after general and regional anesthesia, varies between 0.03-0.4% (1-3). The true incidence is probably under-reported, because of varying definitions, follow-up, and under-estimation of the severity (1-3). Various etiological mechanisms and predisposing factors are described (Table 1) (1, 2, 4-6). Prevention of peripheral nerve injury requires a multidisciplinary approach, in which the anesthetist has an important role in detecting preoperative neurologic risk factors, careful installation of the patient, and managing intraoperative insults.

*Table 1*

Causal mechanisms of perioperative neurologic injuries (1, 2, 4-6)

| | |
|---|---|
| 1) Mechanical | – Tourniquet<br>– Direct trauma by a surgical instrument or needle<br>– Disruption by intraneural injection of fluid |
| 1) Ischemia (hypoxic perfusion through vasa nervorum) | – Hypotension (general or isolated)<br>– Compression and stretch<br>– Vascular trauma<br>– Vasoconstrictive properties of local anesthetics or adjuncts<br>– Predisposing metabolic or electrolyte disorders<br>– Hypoxemia |
| 1) Chemical | – Neurotoxicity of local anesthetics or adjuncts |
| 1) Inflammatory | – Sepsis<br>– Trauma |

## Case description

A 50-year old woman with HNPP was scheduled for a three level thoracic laminotomy for removal of an arachnoid cyst causing medullary compression. She presented with interscapular burning band-shaped pain and a progressively disturbed gait with discrete ataxia and subjective weakness in the lower limbs. Electromyography showed an axonal demyelinating generalized sensorimotor neuropathy, especially in the lower

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limbs, and a somatosensory evoked potential test revealed bilateral impairment of the dorsal column. An arachnoid cyst with medullar compression at level T4-T6 was visualized on the magnetic resonance imaging.

In 2009, she was diagnosed with HNPP after a history of multiple episodes of focal sensorimotor neuropathies, occurring even after short exposure to pressure and stretch. Electrodiagnostic testing revealed a primary demyelinating generalized sensorimotor neuropathy, and the diagnosis of HNPP was confirmed by DNA analysis. Her daily life was moderately affected by recurrent palsies after trivial activities, such as carrying groceries, writing on a blackboard or crossing her legs. Furthermore, she suffered from a postoperative ulnar neuropathy after a lateral epicondylitis release, which recovered after several weeks of physiotherapy.

The surgical procedure in this case report required general anesthesia with prone positioning for more than four hours. During the preoperative preparation, we expected that positioning would be extremely challenging, and we reviewed the available literature for guidance. One letter to the editor described performing regional anesthesia for anterior cruciate ligament reconstruction in a patient with HNPP (7). Four cases were published, which discussed the obstetric management of patients with HNPP (8-11). No reports could be found on general anesthesia management and positioning for major surgery in patients with HNPP.

## Discussion

### *Hereditary Neuropathy with Liability to Pressure Palsies*

HNPP is an autosomal dominant disorder with an incidence varying between 0.84 to 16 per 100 000 persons, characterized by recurrent focal sensorimotor nerve palsies elicited by pressure or stretch (12, 13). Symptoms may vary in degree and duration, and can even be evoked by trivial activities. About 50% of patients with symptoms of HNPP make a complete recovery after a few days to a couple of months. The most vulnerable nerves are the median, ulnar and peroneal nerve, because of their superficial location beneath the skin and adjacent bony structures. Recurrent laryngeal, hypoglossal, and phrenic nerve palsies have also been reported (5,13). Electrodiagnostic tests, such as nerve conduction test (NCT) and electromyography (EMG), demonstrate a primary demyelinating sensorimotor polyneuropathy with conduction delay in both clinically affected and clinically unaffected nerves. A certain degree of axonal degeneration or conduction block may also be present (13). The gold standard for the diagnosis of HNPP is genetic testing, which reveals a deletion (70-80%) or a point mutation (20-30%) of the peripheral myelin protein 22 (PMP22) gene, located at chromosome 17p11.2-12 (13). PMP22 is an essential part of the myelin sheath of peripheral nerves. Mutation causes the production of incomplete myelin sheaths that lead to hypermyelination with aberrant myelin loops, inflicting greater vulnerability to pressure and stretch. Sural nerve biopsy features focal swelling of myelin sheaths and Schwann cell hyperplasia surrounding demyelinated or remyelinating axons, which makes it look like "onion bulbs" or "tomaculae". These findings are characteristic, but not specific of HNPP, as similar histologic changes can be observed in Charcot-Marie-Tooth (13).

### *Pathophysiology of perioperative nerve injury*

Peripheral nerve injuries are a heterogeneous group of disorders that are secondary to various causes. The earliest classification of nerve injuries was given by Seddon (14) and Sunderland (15). This classification, which holds true till date, subdivides peripheral nerve injuries into three types: neuropraxia, axonotmesis, and neurotmesis (14-16). Minor injury causing demyelination leads to loss of nerve conduction velocity (neuropraxia), which recovers rapidly and completely as the myelin sheaths are repaired. If the insult persists or has great magnitude, the loss of myelin can be followed by secondary axonal lesions (axonotmesis). This will lead to further axonal degeneration more distal to the injury, known as Wallerian degeneration, diagnosed as a decrease of compound muscle action potentials (CMAP) and sensory nerve action potential (SNAP) with distal stimulation in an electromyography study. Wallerian degeneration of the distal nerve part occurs approximately two to three weeks after the initial axonal lesion (16). Spontaneous recovery is possible because of the preservation of part of the surrounding supportive glial tissue, including Schwann cells, endoneurium, perineurium and epineurium. If the supportive tissue is also damaged (neurotmesis) spontaneous recovery is very unlikely and surgical repair may be needed (2, 16).

In patients with HNPP, the sheaths surrounding the nerves contain aberrant myelin, and are therefore more prone to demyelination. The loss of nerve conduction velocity depends on the extent

and duration of the injury, as well as the speed of recovery of the myelin sheaths, which explains the clinical presentation variability in patients with HNPP.

The causal mechanisms of peripheral nerve injury can be divided into several categories: mechanical, vascular, chemical, inflammatory or a combination of these (Table 1) (1, 2, 4-6). Commonly used general anesthetic agents are not known to cause direct peripheral nerve injury, but they can however induce systemic arterial hypotension and loss of postural tension, which plays an important role in the pathophysiology of peripheral nerve injury (2).

Despite the numerous measures used in daily practice, perioperative nerve injuries still occur without finding a clear surgical or anesthetic cause. Preoperative risk factors and pre-existing neuropathy play an important role and must be actively searched for and documented (5, 17). In 1973, Upton & McComas formulated a hypothesis called the 'double-crush phenomenon', which has been widely demonstrated experimentally (18). They postulated that the loss of nerve function after a double nerve lesion, at the same location or more proximal or distal from the initial insult, was greater than the sum of each deficit separately. Thus, a pre-existing nerve injury implies a lower threshold for damage at the same or a second locus during a new insult. Pre-existing peripheral neuropathy, with a risk for 'double-crush', has a global prevalence of 2-8%, and even increases to 26% and 58% in patients with diabetes mellitus type 2 and type 1, respectively (5). The most important known risk factors for developing peripheral neuropathy are diabetes mellitus, chronic alcohol consumption, extremes of weight, smoking, malnutrition, pathologies of the spine (e.g. spinal stenosis) and structural neuropathies (e.g. HNPP) (5). If pre-existing neuro-pathy is suspected, documentation is essential and further objective electrodiagnostic testing may be needed to facilitate baseline comparison.

*Anesthetic management*

Preoperatively, our patient was extensively informed of the risks of this procedure, requiring prone positioning for several hours. A simulation of the positioning of the patient was performed by the attending anesthesiologist in order to identify the critical pressure and traction points (Figure 1). A simulation with the awake patient may had been better, but the psychological impact of such a measure should not be underestimated.

Fig. 1. — At the top, a picture of the preoperative simulation in the prone position done by the attending anesthesiologist. It is meant to identify the pressure points and to find the most optimal posture for the high risk patient who is to undergo surgical treatment. At the bottom, a picture of the patient during installation with her head fixed in a Mayfield® head clamp. There is no pressure on her forehead or face, and the head of the patient can easily be positioned in the neutral position. Her limbs are wrapped in quilted cloths and placed in the neutral position with no pressure on feet and knees (Picture is published with written informed consent of the patient).

After induction of general anesthesia, the patient was intubated with a size 7.0 tracheal tube, which was carefully fixed with tape to prevent traction on the lips and vocal cords. Cuff pressure was monitored with a manometer (Covidien$^{\circ}$) and was maintained in the indicated safe zone below 33 $cmH_2O$ during the entire procedure. We preferred invasive blood pressure monitoring through a radial arterial line over a non-invasive intermittent oscillometric blood pressure measurement. This avoided repetitive inflation of the blood pressure cuff with potential neurologic insult, and provided a more accurate hemodynamic monitoring (19). Such a close monitoring of arterial blood pressure allows early detection of low blood pressure episodes and their early correction to avoid potential nerve ischemia.

The patient was turned in the prone position, corresponding to the position that was acquired during the preoperative simulation. The head of the patient was fixed in a Mayfield® head clamp (Figure 1), to prevent pressure on facial structures and eyes. The Mayfield® head clamp also allowed installation with a neutral position of the head and

neck to exclude traction on the brachial plexus. As this was a neurosurgical procedure, the whole team was familiar with the installation of this clamp. A good positioning of the limbs was crucial to avoid direct compression and stretch, and to maintain a good arterial perfusion of the peripheral nerves. Therefore, all limbs of the patient were wrapped in quilted cloths, and protected with gel pads. Both arms were opposed to the body, with special attention to the superficial parts of the ulnar and radial nerve, and support of the hands to avoid traction on the wrists. Both legs were positioned with attention to pressure points, and with clearance of the common peroneal nerve (Figure 1). During the surgical procedure, the positioning was reassessed every hour (5). For operations lasting longer than three hours, it is advised to relieve stretch and pressure points for at least 10 minutes, 15 minutes being preferable, to prevent neurologic damage (5). To maintain adequate oxygen delivery to the tissues, including peripheral nerves, mean arterial blood pressure was held above 65 mmHg and within 20% of the baseline value, according to general practice (20, 21).

The operation lasted for four and a half hours, and was a success. Blood loss was estimated to be less than 50 mL. The patient woke up without complications, and was installed in a bed with a Quattro plus® pressure relieving mattress. She had no new neurologic deficits or discomfort at the Mayfield®'s clamping points after the operation.

During the first postoperative day, the patient complained of paresthesia in the ulnar region, which arose after holding a book. She was familiar with this situation and the symptoms spontaneously disappeared and recovered with a remarkable improvement of strength in her lower limbs and resolution of her preoperative complaints. She continued treatment for interscapular pain. She did not develop perioperative neurologic deficits that could be directly related to the procedure.

## Conclusion

The cause of perioperative nerve injuries is multifactorial and difficult to comprehend. They are not uncommon in daily practice of many surgeons and anesthesiologists, both after regional and general anesthesia. A preoperative anesthetic consultation should include screening for preexisting neurologic symptoms and risk factors for subclinical peripheral neuropathy. If necessary, a formal neurologic exam with electrodiagnostic tests is needed to document the baseline status and to investigate if genetic testing is indicated. High-risk patients should be well informed preoperatively. A careful approach should be taken, tailored to the specific needs of the planned surgery, and with involvement of the whole operative team.

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