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REVIEW

Post-operative nerve injuries after cervical spine surgery

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Abstract

Although relatively rare, post-operative nerve injuries may occur after cervical spine procedures. The most common post-operative neural disorder is C5 nerve palsy. The risk factors for C5 nerve palsy are male gender, OPLL, and posterior cervical approaches. It generally presents with deltoid and/or biceps weakness, and may present immediately or several days after surgery. Treatment is generally conservative due to transient duration of symptoms, but evaluation of residual compression at C4–5 is essential. PTS (Parsonage-Turner syndrome) is an idiopathic plexopathy generally presenting with severe neuropathic pain in the shoulder, neck, and arms, followed by neurological deficits involving the upper brachial plexus. The deficits typically present in a delayed fashion after the onset of pain. Once residual nerve compression is ruled out, initial treatment is based on pain control and physical therapy. Post-operative C8-T1 nerve palsies occur with weakness of the five intrinsic muscles of the hand innervated by the medial nerve, with sensory symptoms in the territory innervated by the ulnar nerve (ulnar two digits of the hand), and also the medial forearm. The risk factors for C8-T1 nerve injuries after surgery are C7 pedicle subtraction osteotomies and posterior fixation of the cervico-thoracic junction, especially in patients with preoperative C7-T1 stenosis. A wide foraminal decompression at C7-T1 region is necessary to minimize risk of this complication. Finally, Horner's syndrome can occur post-operatively, especially after anterolateral approaches to the middle and lower levels of the cervical spine. It is characterized by ipsilateral papillary miosis, facial anhydrosis, and ptosis secondary to injury of the cervical sympathetic nerves. Avoid using the cautery on the lateral border of the longus colli muscle, where the sympathetic chain lies and place the retractors properly underneath the muscle to decrease the chance of sympathetic injuries. It can also occur from iatrogenic compression or injury to the T1 nerve root, as the sympathetic chain gets some of its fibers from that level. Understanding the most common potential nerve injuries after cervical spine procedures is helpful in prevention, early diagnosis, and appropriate management.

Key-words C5 nerve root palsy cervical spine surgery · C8-T1 nerve palsy · Parsonage-Turner syndrome · Horner's syndrome · Idiopathic brachial plexopathy · Neuralgic amyotrophy

Abbreviations

OPLL	Ossification of the posterior longitudinal ligament
PTS	Parsonage-Turner syndrome
EMG	Electroneuromyography

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Introduction

Cervical spine surgery is fraught with a variety of possible complications. While potentially devastating, neurological injuries after cervical spine surgery are fortunately uncommon [1]. These injuries can range from nerve root injuries to spinal cord injury.

Spinal cord injury is extremely rare after a cervical procedure. The risk of cord injury with permanent neurologic deficit is estimated at about .011% [1]. A large, recent, multicentre retrospective cohort study of prospective collected data reported that, from 17,625 patients who received cervical spine surgery (levels involving from C2 to C7), there were three cases of iatrogenic spinal cord injury (quadriplegia), with one with complete neurologic recovery, one partially recovered, and one without any motor improvement [1].

Nerve root injuries secondary to cervical spine surgeries are still infrequent but much more common. Post-operative C5 palsy, Parsonage-Turner syndrome (also known as idiopathic brachial plexus neuropathy or neuralgic amyotrophy), C8-T1 radiculopathy, and Horner's syndrome are potential complications of cervical spine procedures [2–4].

In this paper, we discuss the most common nerve root complications after cervical spine surgery, focusing on strategies for prevention and early diagnosis.

Post-operative C5 nerve palsy

The clinical presentation of C5 palsy is generally a unilateral deltoid and a biceps muscle weakness with diminished biceps reflex (although it may be bilateral in 5 to 7% of the cases) [3, 5–8]. The deltoid is innervated by the axillary nerve (generally the ventral ramus of C5 via the superior trunk and posterior cord of the brachial plexus) [6–8]. C6 contribution is usually nonexistent to the deltoid. The biceps brachii may also have some weakness once the musculocutaneous nerve arises from the lateral cord of the brachial plexus with root contribution of C5 (and also C6 and C7).

The definition of C5 palsy has varied in the literature. Bydon et al. have described it as a deltoid motor decline of at least one level in standard manual muscle testing (MMT) within the first six weeks post-operatively [6]. Other definitions have stated that there must be a MMT score of 3, or a motor deficit of at least one level in MMT of the deltoid and/or biceps without changes in the lower extremity function [7, 8].

C5 nerve root palsies after cervical spine surgery is associated with nearly all types of cervical procedures, regardless of whether surgery is performed anteriorly or posteriorly. In a large multicentre study with 13,946 patients who had cervical spine surgery (levels C2 to C7), across 21 centres, a total of 59 cases were reported [3]. The incidence of C5 palsy ranged from 0 to 2.5% among the different centres, with about 54.4% of the patients affected reporting complete resolution of symptoms, 25.4% had residual effects, and 17% did not exhibit any recovery [3].

In a recent meta-analysis, Wang et al. reported that, from 721 patients with postoperative C5 palsy from 61 studies, the risk factors identified were: male gender (5.9 versus 4.1% in females), posterior cervical approaches (6.2 versus 5%), and patients with ossification of the posterior longitudinal ligament (8.1 versus 4.8% of those patients with cervical spondylotic myelopathy [9]. Anterior cervical discectomy and fusion (ACDF) had a lower incidence (5.5%) and posterior laminectomy and fusion higher (13%) for C5 palsies [9].

A precise explanation for C5 palsy after cervical spine surgery is not agreed upon, but theories include single innervations of the deltoid muscle, surgical technique used, previous spinal cord injury, thermal injury from high speed drill, ischemia and reperfusion of the spinal nerve and spinal cord, tethering the nerve with shifting of the spinal cord after decompression, vulnerability to traction once it is in the centre of cervical lordosis, and a horizontal and shorter trajectory of the roots [10–12]. Intra-operative direct C5 nerve root injury is a possibility that may be diagnosed intra-operatively, especially with the use of intra-operative neurophysiological monitoring; this would be manifested immediately after the patient awakens from anaesthesia [13].

Preventative measurements may include a prophylactic C4–5 foraminotomy. Liu et al. reported the results of a retrospective study in which 70 consecutive patients underwent an open-door laminoplasty with bilateral C4–5 foraminotomies [5]. They reported that four patients (5.7%) had C5 palsy despite the preventive C4–5 bilateral foraminotomies. After a multivariate analysis, two primary statistical risk factors were identified for post-operative C5 palsy: long duration of pre-operative symptoms (>12 months) ($p < 0.0001$) and the presence of pre-operative C4–5 T2 MRI signal cord changes ($p = 0.036$) [5]. They concluded that, even despite bilateral foraminotomies, post-operative C5 palsy might occur.

C5 palsy may become apparent immediately after or up to two weeks after surgery [3]. Treatment is usually conservative, since most of the cases are transient, (about 70% recover completely) but is important to rule out instrumentation failure and neurologic compression with radiographic imaging [3]. Steroids may be used but there is no clear evidence of their benefits. If compression persists, a new surgical approach may be advisable. Surgeons should be mindful to distinguish C5 nerve palsy from Parsonnage-Turner syndrome (see below). Residual pain despite muscular strength improvement is reported in about 20% of the cases.

Parsonnage-Turner syndrome

Parsonage-Turner syndrome (PTS), otherwise known as idiopathic brachial plexopathy or neuralgic amyotrophy, is characterized by a sudden onset of pain, which can be accompanied by neuropathic characteristics in the neck, shoulder, and arm [2]. After some hours or even days, patients often develop motor weakness with or without sensory abnormalities [2, 13]. The motor symptoms generally involve the upper brachial plexus and a winging scapula is found in about half of the cases [13]. PTS may be incited classically by viral infections, but also can occur after extreme physical exercise, pregnancy, or surgical procedures. It is possible for PTS to develop after cervical decompression, which makes differentiating this syndrome from C5 palsy difficult.

Post-operative PTS could potentially be underdiagnosed, since it is often a diagnosis of exclusion; the constellation of symptoms could be instead interpreted as being due to technical error or positioning injury. Brown et al. reported six cases of PTS after cervical decompression, five of them with the C5 myotome involved.

The main characteristic of PTS is that the deficit presents in a delayed fashion, and is preceded by severe pain. Similar to C5 palsy, CT myelogram, or an MRI is necessary to rule out neural compression. Another clinical characteristic that may raise the suspicion of PTS is that muscle weakness, sensory changes, and pain does not necessarily involve the same nerve root or peripheral nerve distribution [2, 13]. Pain is generally unaltered by the neck or arm movement.

The main treatment modalities for PTS after cervical spine surgery are pain control and physical therapy to maintain the range of motion of the affected extremities. There is no clear evidence for the efficacy of steroids. An EMG with nerve conduction study can be obtained some weeks after surgery (at least 3 weeks may be necessary to diagnose a plexopathy). An MRI of the affected muscles may show T2 signal changes. In patients who do not show any recovery, nerve transfer procedures may help restore function.

Post-operative C8-T1 nerve palsies

C8-T1 radiculopathies (originating from root compressions between C7-T1 and T1–2) are relatively rare, representing only 6.2% of all cervical radiculopathies [14]. They are commonly misdiagnosed as ulnar neuropathy secondary to compression at the elbow, also known as cubital tunnel syndrome [15]. Clinically, C8-T1 radiculopathies result in weakness of all of the intrinsic muscles of the hand [15]. With cubital tunnel syndrome, only the ulnar innervated muscles are affected, sparing the five intrinsic hand muscles that are innervated by the median nerve: the abductor pollicis brevis, the flexor pollicis brevis, opponens pollicis, and lateral lumbricals. The mnemonic for these five median nerve innervated muscles is "AbOF the Law (Abductor, Opponens, Flexor and Lateral lumbricals)," the law being that all intrinsic hand muscles are ulnar nerve innervated and that these are above that law [15].

Additionally, C8-T1 radiculopathies also present with numbness in the fourth and fifth fingers and the ulnar border of the hand, similarly to ulnar neuropathy at the elbow, but also involves numbness in the medial forearm, which is due to cutaneous supply by the medial antebrachial cutaneous nerve (which does not come from the ulnar nerve but it is supplied by the medial cord of the brachial plexus) [15]. This sensory change at the medial forearm does not occur in ulnar cubital tunnel syndromes. In addition to the clinical examination, an EMG/NCS study may also help in differentiating these diagnoses.

C8-T1 radiculopathies are probably the most common cause of neurological injury after a C7 pedicle subtraction osteotomy (PSO) [16]. To avoid this often transient but potentially permanent injury, a wide posterior nerve root decompression above and below the pedicle of C7 is advisable.

Post-operative C8-T1 radiculopathy may also occur after long posterior cervico-thoracic fusions. This may be more common in patients with pre-existing foraminal stenosis at the cervico-thoracic junction. Wide foraminal decompression at C7-T1 is advisable in patients with radiographic stenosis who are to undergo instrumented arthrodesis in extension. As part of the pre-operative workup of such patients, we place the patient in a supine position during their office visit, with their neck extended for several minutes. If they develop paresthesias or pain in their arms, we perform prophylactic foraminotomies at all stenotic levels from C4–5 on down.

Horner's syndrome

Horner's syndrome is characterized by ipsilateral pupillary miosis, facial anhydrosis, and ptosis from damage to the cervical sympathetic nerves [17]. It is a rare complication of the anterior approach to the cervical spine and may cause severe distress due to the resulting impaired cosmesis [17]. The sympathetic nerves and trunk may be damaged by prolonged retraction or even injury of the longus colli muscle, once the trunk courses over the anterior surface of the muscle [4]. In the middle and in the lower cervical spine, the sympathetic trunk is more medially positioned along the muscle, increasing the chance of injury during anterolateral approaches [4].

The incidence of Horner's syndrome in 17,625 patients was 0.06% (only five cases); all of these cases were reported after ACDF. These occurred more often from surgery at the C5–6 level, with most patients presenting with at least partial recovery without additional management (two patients with complete recovery and one patient with partial recovery) [4]. Improvement generally occurs after three to six months [4, 18–20]. However, transient Horner's syndrome after oblique corpectomies has been reported in 73 of 465 patients (15.7%), while 16 cases (3.4%) resulted in permanent damage [4].

The likelihood of post-operative Horner's syndrome can be minimized with care not to apply monopolar cautery laterally on the longus colli muscle, as well as by avoiding the use of retractor blades above the muscle, especially when at the C5–6 level [4]. Maintaining a midline trajectory and performing a subperiosteal dissection of the muscle to properly place the retractors may decrease the risk of sympathetic nerve root injury.

Horner's syndrome has been reported with T1 radiculopathies, as well as injury to the cord at the

Table 1 Clinical presentation, diagnosis, risk factors, differential diagnosis, and preventative measurements of nerve injuries after cervical spine procedures

Clinical scenario	Risk factors	Clinical presentation	Physical examination	Differential diagnosis	Preventative measures
C5 palsy	-Male -Posterior cervical surgery involving C4–5 -OPLL	-Postoperative (immediately or after up to 14 days) weakness of the deltoid muscle or biceps Often painless	-Weakness of the deltoid or biceps muscle -Mild or absent sensory symptoms	-Parsonage-Turner syndrome -Foraminal stenosis/-incomplete decompression at C4–5	-Thorough C4–5 decompression -Care to not injure C5 nerve root intraoperatively with heat or surgical instruments
Parsonage-Turner syndrome or idiopathic brachial plexopathy or neuralgic amyotrophy	-Infection -Systemic stress -Surgeries -Cervical decompression	-Usually severe neuropathic pain before motor deficit	-Involvement of C5 myotome but also muscle weakness and sensory symptoms not necessarily in the same nerve root or peripheral nerve distribution -Winging scapula	-C5 palsy -Incomplete decompression	
C8-T1 radiculopathy	-Cervico-thoracic fusion -C7 pedicle subtraction osteotomies -C7-T1 stenosis	-Symptoms in the territory of the ulnar nerve but also involvement of the medial forearm and hand weakness of the five intrinsic hand muscles innervated by the median nerve	-Sensory symptoms in the medial forearm, 4th and 5th fingers and also ulnar border of the hand -Weakness of all intrinsic hand muscles, including the median nerve innervated muscles (abductor pollicis brevis, flexor pollicis brevis, opponens pollicis, and lateral lumbricals)	-Ulnar compression at the elbow	Adequate C7-T1 decompression when pre-existing radiological stenosis exists Preoperative evaluation of patient with neck extended for sensory symptoms in the medial forearm
Horner syndrome	-Oblique lateral corpectomies -Lateral anterior cervical approaches -Middle and lower approaches to the subaxial cervical spine (C5 level)	-Ipsilateral pupillary miosis, facial anhydrosis, ptosis	-Difficult to open the ipsilateral eyelid and miosis with decreased sweating and apparent enophthalmos	-Apical lung tumor (Pancoast tumor) involving the sympathetic chain -Specific pupil diseases or third nerve palsies -Cord injury at cervico-thoracic junction -T1 radiculopathy	Avoiding monopolar cautery laterally on longus colli -Subperiosteal dissection and maintaining retractors underneath longus colli

cervicothoracic junction. Sympathetic fibers originate from the hypothalamus and pass thru the intermediolateral gray column of the spinal cord, exiting at T1–2. Therefore, lesions involving the T1 nerve or the spinal cord near the nerve can result in a Horner's syndrome (Table 1).

Conclusions

Knowledge of the most common potential nerve injuries after cervical spine procedures is necessary to minimize their occurrences, as well as to diagnose them early and offer patients proper information about their natural history and possible treatment options.

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