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Case reports

A case of bilateral "double/multiple crush" entrapment syndrome of the upper limbs in a violinist

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Abstract

Entrapment syndromes of the upper limb are common neuro-muscular-skeletal pathology in musician instrumentists. From this group of morbid entities, the most prevalent worldwide is carpal tunnel syndrome closely followed by the cubital tunnel syndrome and de Quervain stenosing tenosynovitis. Due to their distinctive etiopathogenic correlation with exposure to specific occupational factors linked to instrument interpretation and professional environment, these diseases raise a medical challenge and constitute a socioeconomic and professional burden with legal branchings and implications for individuals and society. These syndromes develop isolated or more often in various associations with each other in a clinical pattern that has been described under the model of "double crush" syndrome by Upton and McComas. From its inception in 1973 until the present time, this clinical model has been a point of interesting debate between various specialists worldwide. This model underlines an already lesioned neuron's susceptibility and vulnerability for further neural damage at a different level from the initial lesion. The sophisticated clinical presentation of this "double or multiple crush" syndrome is due not only to overlapping symptomatology from each contributing neuro-muscular-skeletal pathology or lesional site but also to other local or systemic conditions such as trauma, diabetes, osteoarthritis, thyroid disease, obesity, etc. The occupational factors such as repetitive movements, strain and overload, vibrations, ergonomics, and others all contribute to the creation and progression of the morbid process. We cannot overstate the implications of understanding these complex relations and interdependencies between the factors mentioned above as they are essential not only for the diagnosis of these neuropathies but also for the treatment, rehabilitation, and occupational reinsertion of the patients. The studies support the fact that both lesional sites need to be medically addressed for an optimal outcome and resolution. We present the case of a female violinist with bilateral multiple neuro-muscular-skeletal pathologies of the upper limb treated previously invasively and conservatively over several years by various specialists without a satisfactory clinical resolution of the symptomatology or any professional and legal measures taken.

Keywords: *upper limb entrapment syndromes, carpal tunnel syndrome, cubital tunnel syndrome, de Quervain's tenosynovitis, double-crush syndrome, occupational factors*

Introduction

Upper limb entrapment syndromes are a group of very diverse neuromuscular-skeletal pathologies that affect the functional capacity of many patients ranging from mild to severely disabling and with significant socio-economic-professional repercussions for both individuals as well as for society. We list some of the morbid entities from this group: cervical radiculitis and brachial plexopathy, thoracic outlet syndrome, pronator teres syndrome, cubital tunnel syndrome, radial tunnel syndrome, carpal tunnel syndrome, Guyon tunnel syndrome, de Quervain stenotic tenosynovitis, etc. The most common in the world is the carpal tunnel syndrome, closely followed by the cubital tunnel syndrome, which are practically biomechanical and pathogenetic models useful for understanding the whole group of entrapment syndromes.

The "double-crush syndrome" was first reported by Upton and McComas [1] in 1973 and is still widely debated by experts. The proposed model refers to double or multiple damages at different levels of the axonal/dendritic structures of a single nerve. Thus appears a complex and intricate clinical picture caused by the overlapping of specific and nonspecific symptoms of each lesion, which raises many problems of differential diagnosis and requires a therapeutic approach to each lesion individually to cure or improve the neuropathy as a whole. Epidemiological studies have highlighted the association of occupational, individual, and psychosocial risk factors in these diseases' etiopathogenesis. The most common occupational risk factors are repetitive movements, wear and tear and musculoskeletal and joint overload, prolonged maintenance of forced postures, bad non-ergonomic postures of the body, and the upper limb and exposure to vibrations caused by tools or vibrating instruments. A series of extra-occupational factors can contribute to the appearance of these neuro-musculoskeletal disorders. Among them, we mention female sex, obesity, pregnancy, diabetes, thyroid diseases, osteoarthritis, soft tissue diseases.

Our presentation reports a case of occupational neuro-musculoskeletal pathology of the upper limb and cervical spine associated with the violinist occupation. This category is frequently affected by these morbidities.

Case Presentation

Our case concerns a 49-year-old patient admitted in 2017 at the Occupational Medicine Clinic from Colentina Hospital Bucuresti for pain in the left elbow joint accompanied by paresthesias in the fingers IV-V ipsilaterally with nocturnal exacerbations. The active mobilization, passive flexion, and extension of the bilateral radio-carpal and carpometacarpal joints exacerbate the pain with bilateral partial functional impotence more accentuated at the left-hand level.

The patient is a violin instrumentalist in a symphony orchestra with 24 years of experience. According to the employer's occupational risk factors identification sheet, the occupational activities include not only artistic-specific activities (as orchestra rehearsal programs, daily rehearsals, additional general rehearsals, and concerts) but also occupation-specific activities (as tunning the instrument before use, changing the strings when they break). These conditions mentioned above expose the musician to repeated microtraumas, intense and repetitive movements in the upper limbs (shoulder, elbow, fist), osteo-muscular-articular overloads, overall low physical effort, predominantly seated position, forced non-physiological positions (position-specific to playing the violin), auditory overload, neuro-psycho-sensory overload (mental and emotional), pulsating noises, mechanical vibrations in the spine, upper limbs and on the whole body.

History of present illness

The algic symptomatology debuts insidiously during 2005 with cervical pain and paresthesias that irradiate in the medial region of the left arm, left forearm, and left-hand fingers IV-V. The imagistic studies performed in 2005 during hospitalization in a neurosurgical clinic showed left cervical degenerative disk disease C8-D1, phase III, stage I. By continuing to practice the profession despite outpatient anti-inflammatory treatment, physiotherapy, local infiltrations with steroidal anti-inflammatory drugs, ozone therapy and swimming that only led to short-term improvement in symptoms, patient's cervical pain persisted and worsened

Previous medical examinations to clarify neuro-musculoskeletal pathology have diagnosed in chronological order: C8-T1 cervical degenerative disk disease(2005), left metacarpophalangeal index synovial cyst (diagnosed and operated in 2009), left carpal tunnel syndrome (diagnosed and operated in 2009), aseptic necrosis of the left scaphoid at CT examination (in 2012), degenerative subcortical cysts of the trapezius and capitate and carpometacarpal osteoarthritis changes of the joint of the metacarpal

II with proximal (radio-scaphoid) chondropathy of the left scaphoid (on the MRI examination (2013), dorsal radio-carpal synovial cyst (diagnosed and operated in 2012), tenosynovitis and tendonitis of long abductor tendons, short extensor, long extensor of the thumb, common extensor of the fingers, long and short radial extensor of the carpus of the right hand by postoperative scar fibrotic adhesions (from surgery in 2009) diagnosed and operated (04.2015), tunnel syndrome left ulnar (diagnosed and operated in 12.2015). In 2017, the patient underwent surgery with fat and stem cell transplantation (lipofilling) for tendinitis and right-hand de Quervain tenosynovitis. For each surgery, the professional activity was interrupted only during the surgical treatment and the postoperative recovery period within the allowed legal limits. After that, the patient returned to work without restrictions. The last neurosurgical evaluation (02.2017) highlighted the presence of cervical vertebral cervical degenerative disk disease C5, C6, C7 phase IV, lumbar degenerative disk disease phase III / I, long extensor policis tendon bilateral, bilateral radio-carpal osteoarthritis with algic syndrome.

Personal past medical history besides the already mentioned above also includes appendicectomy (at 12 years age), cholecystectomy (2002), chronic frontal sinusitis (2010), severe rhinoconjunctivitis, hypertension (hypertension) grade III (2016), hypercholesterolemia (2016), atheromatous right carotid with soft plaques (2016), thyroid node at the isthmus and right lobe (2016) and left upper eyelid cyst operated (2017). Among the family history antecedents, hypertension is notable for the mother, and type II diabetes and stroke for the father. The patient is allergic to cereals, cobalt chloride, and follows a cardio-maintenance treatment with Aspirin 1cp 0.75mg/ day.

Case report

Overweight patient (BMI = 27.34), T = 36.5C, TA = 160/100 mmHg, HR = 90 bpm, RR = 18/min, SpO_2=98% (room air), has postoperative bruising on the upper eyelid left and at the level of the external angle of the left eye, bilateral pterygium, dentition with deficiencies and multiple dental works, painful frontal sinuses points, scars after laparoscopic cholecystectomy, scars after appendicectomy, two scars at the umbilicus after lipid and stem cell transplantation. The skeletal and articular musculoskeletal examination shows: straightness of the cervical spine, dorso-lumbar kyphoscoliosis and compensatory lumbar lordosis, pain at percussion of the cervical spinous processes, scars of about 7 cm length at the left elbow after surgery for ulnar canal syndrome (Figure 1), scar of about 4 cm at the level of the left radiocarpal joint region after carpal tunnel

Figure 1. Postoperative scar for left cubital tunnel

Figure 2. Dorsal aspect of hands and wrists

Figure 3. Palmar aspect of hands and wrists

syndrome surgery, scar of about 3 cm at the dorsal face of the left wrist after synovial cyst surgery, scar of about 4 cm on the palmar aspect of the left index finger post synovial cyst surgery, scar of about 8 cm on the dorsal face of the right hand after synovial cyst surgery (Figure 2,3), limitation of the V finger extension bilaterally, positive Finkelstein test on the right (adduction with the opposition of the thumb inside the clenched fist, followed by its ulnar deviation produces an algic response on the dorsal surface of the thumb, wrist and forearm at the level of the tendons M. extensor pollicis brevis and M. abductor pollicis longus), normal bilateral Allen test (radial and ulnar artery patency).

Neurological examination of the upper limbs (Table 1)

Left median nerve: bilateral negative Durkan test (carpal tunnel compression for 30-60s with eliciting the pain response if positive), Tinel test (percussion of the area of interest with eliciting response in our case the percussion of postoperative scars) was negative in the left palmar radiocarpal area, negative Phalen test bilaterally (maximum flexion in opposition of both hands with 1-2min hold causes paresthesia and pain in the sensory territory of the median nerve if positive).

Left ulnar nerve: positive Froment sign (flexion of the distal phalanx of the thumb highlighted by holding a sheet of paper between the thumb and forefinger denotes the weakness of the adductor muscle of the thumb innervated by the ulnar nerve). The Tinel test was positive (percussion of the dorsal aspect of the left ulnar epicondylar-medial area just above the postoperative scar). The ulnar flexion test is positive on the left and negative on the right (The patient actively flexes the ulnar joint at 1200 starting from the position of the relaxed arms, along the body and maintains the flexed position for 3 minutes. Reproduction of pain and paresthetic symptoms is a positive test). The pressure challenge test is positive left and negative right (compression applied proximal to the cubital ulnar tunnel with the elbow flexed at 200 in supination – [2].

Right radial nerve: Tinel test positive for percussion of the right dorsal radio-carpal area, respectively, the supination test of the forearm against resistance is negative (elicitation of pain in the elbow and forearm is pathognomonic for radial tunnel syndrome), hyperextension test of right hand against resistance is positive (local pain elicits), finger hyperextension test III against resistance is negative (forearm pain elicitation is pathognomonic for radial tunnel syndrome) [3]. The "rule of nine" test was not applied (palpation testing of the pain sensitivity of the posterior interosseous branch of the radial nerve in the anterior ulnar area divided into nine quadrants - this nerve branch crosses most often the lateral quadrants)[4].

The patient presents with superficial hypoaesthesia in the anteromedial face of the left forearm, hyperesthesia in the posteromedial face of the left forearm, limitation of the bilateral grip strength (left> right) caused by exacerbation of pain symptoms, osteotendinous reflexes +2 bilaterally (triceps normal, biceps normal, brachioradialis interfered by maneuver eliciting local pain).

Paraclinic and Imaging investigations

Successive ultrasound examinations in 2015, 2016, and 2017 show arthritic changes in the radiocarpal region, moderate rhizarthrosis of the thumb, moderate inflammatory changes of the metacarpophalangeal (MCP), proximal interphalangeal (PIP) and distal interphalangeal (DIP) of the right-hand fingers II-III suggesting the persistence of De Quervain's tenosynovitis, tendinitis of the extensor policis longus and the extensor carpi radialis by partial inclusion in the postoperative scar. On the left hand and elbow, there are noticeable local edemas of the ulnar nerve without focal mass in the area of the elbow passage, arthritic and inflammatory changes at the radiocarpal, metacarpophalangeal (MCP), proximal interphalangeal (PIP) and distal interphalangeal (DIP) fingers II-V also suggesting tendinitis of the extensor carpi radialis possibly on the background of overuse strain and local scar conflict. The electromyography (EMG) performed on 19.12.2016 examined the median, ulnar, radial nerves bilaterally and concluded a diminished amplitude of the right radial nerve's sensory response. The anterior left interosseous nerve EMG did not show detectable spontaneous pathological activity. Motor drive potentials were of normal duration and amplitude. The radiology examination of the cervical spine (performed in 02.2017) showed changes in cervical spondylosis by narrowing of the intervertebral spaces C5-C6, C6-C7, and C8-T1, osteo-condensation of adjacent vertebral plates, posterior and anterior-inferior marginal osteophytes and changes in the level of the anteroinferior small posterior cervical joints (Figure 4).

Recommendations upon discharge: avoid physical exertion, prolonged orthostatism, overuse of the

Table 1. Upper limb nerves and their specific clinical tests and maneuveurs

	Test	Left	Right
Median nerve	Durkhan	negative	negative
	Tinel	negative	negative
	Phalen	negative	negative
Ulnar nerve	Tinel	positive	negative
	ulnar flexion	positive	negative
	pressure challenge	positive	negative
Radial nerve	Tinel	positive	negative
	supination against resistance	negative	negative
	wrist hyperextension against resistance	positive	negative
	middle finger extension against resistance	negative	negative

Figure 4. Lateral view of cervical spine and skull X-ray

cervical spine, and upper limbs bilaterally, unfavorable microclimate conditions (cold and humidity). We discharged the patient with recommendations for articular rest of the elbow joint and bilateral radio-carpal joints, medical-gymnastics, physiotherapy, non-steroidal anti-inflammatory drugs (NSAIDs) as needed, medical collar for pain, a diet rich in protein and vitamins, daily intake of at least 2 liters of fluids, periodic control, and monitoring through the specialties of neurosurgery, orthopedics, cardiology, balneary cures and physiotherapy with kinesiotherapy, medical rehabilitation, allergology, endocrinology, and family medicine. We believe that the patient should consider professional reorientation following the evaluation of the work capacity and work fitness. Treatment: topical and oral non-steroidal anti-inflammatory drugs (NSAIDs), antihistamines, spa treatment - with the advice of a cardiologist. Medical leave during hospitalization and 14 days at discharge. Control in the clinic over two years - by appointment.

Diagnosis

1. Tendinitis and occupational tenosynovitis of the tendons (m. abductor pollicis longus, extensor policis brevis, extensor pollicis longus, common extensor digitorum communis, extensor carpi radialis longus et brevis) of the right hand.
2. Occupational cervical vertebral degenerative disease C5-C7, C8-T1 (overloading the cervical spine by over-tensioning, pressure, prolonged forced positions)
3. operated left carpal tunnel syndrome, (considered cured after surgery can no longer be declared as an occupational disease by Romanian law)
4. operated left ulnar canal syndrome, (considered cured by surgery can no longer be declared as an occupational disease by Romanian law)

We established the diagnosis of occupational disease for two of the above diagnoses as occupational disease rank one according to Romanian laws (BP1).

We support the occupational character based on the official documents that proove the professional exposure (copy of the workbook, REVISAL extract, Occupational Risk Factors Identification Sheet), the professional anamnestic data, which underlines the specifics of the violinist artist professional activity within the orchestra, as well as the exposure to overloads, over-tensions (cervical spine) and repetitive movements (upper limbs) that this activity implies.

Discussions

To better understand this case, it is necessary to briefly review the anatomical-pathophysiological bases of present and past morbid processes and some information pertinent to the occupation of our patient.

The Double Crushing Syndrome (DCS)

Double crush syndrome has provoked much controversy [5-7] shortly after being first described by Upton & McComas [1]. According to this theory, the presence of a proximal lesion increases the vulnerability and predisposition to develop a distal lesion through disorders of axonal transport kinetics and by altering the integrity of the neurofilament architecture. At the same time, when the double crushing syndrome is clinically present, the treatment of both lesion sites is the one that determines optimal results [8-10]. The DCS theory was supported by the experimental model initiated by Nemoto on the sciatic nerve in dogs [11] and by Narakas' research on the association of thoracic opening syndrome with carpal tunnel syndrome, ulnar neuropathy and radial tunnel on the model of DCS [12]. Modern anatomy and neurophysiology knowledge of the DCS model underlinings do not appear to provide a generally satisfactory explanation to all clinical situations with established damage of the anterior motor branch of the spinal nerve (axon of the motoneuron in the anterior medullary horn) and damage to the distal portion of the accompanying sensory fibers of the respective nerve, yet without any demonstrable lesion to the dorsal sensory root of the spinal nerve in a similar "double-crush" pattern (the axon of the sensory neuron in the spinal ganglion is almost exclusively intramedullary).

Different levels of medullary origin for the sensory and motor fibers of the same nerve (e.g., the median nerve has the sensory fibers originating in C6-C7 and the motor fibers in C8-T1) have produced multiple controversies and study hypotheses for validation or invalidation of the DCS model [13]. Differences in neuronal transport between the efferent motor neuron axon and the afferent sensory neuron dendrite also generated the hypothesis of an inverse DCS in which the distal lesion can generate a proximal secondary lesion by interfering with retrograde and anterograde neuronal transport [5]. Some researchers have correlated the presence of DCS with metabolic vulnerability initiated by vascularity changes, blockage of lymphatic drainage of the perineurium and endoneurium [8]. We speculate that possibly due to the specific distribution of sympathetic fibers at different anatomical levels of nerve structures [14], the clinical implications arising from these considerations (e.g., neurogenic inflammation, neuro-immune links and other) new avenues of research and discussions around the concept of DCS may open in the near future. Some proponents of the DCS model felt the need to expand the focus from the synergistic correlation of different nerve injury levels in the original Upton and McComas model to the synergistic effects with systemic comorbidities. Some authors underlined that the amplified pathogenetic effect on the nerve via the action of mechanically compressive factors with the concomitant use of neurotoxic drugs or changes in neural trophism induced by diabetes, peripheral vasculopathy or autoimmune diseases, could create a different "extra-crush" on the nerve under the name of multifocal neuropathy [15].

Entrapment syndromes

The professional etiology of this group of morbid entities primarily recognizes exposure to overload, and biomechanical wear through repetitive movements, excessively maintained postural stances, and exposure to vibrations. These types of exposures can cause not only anatomical changes such as hypertrophy of the ligaments and fascial structures (the transverse carpal ligament in the carpal tunnel syndrome, Osborne's arched ligament in the cubital tunnel syndrome, the Frohse fibrous arch in radial tunnel syndrome) but also loco-regional metabolic changes accompanied by edema, vascular and lymphatic circulatory disturbances and neuro-autonomous imbalances. In the case of the cubital tunnel syndrome and radial tunnel syndrome, the repetitive microtraumas associated with flexion and extension movements of the elbow can lead to edema, perineural lesions with scarification followed by nerve compression inside the respective muscular osteo-fibrous tunnels. For example, during forced flexion, the medial collateral ligament and the epitrochlear ankle muscle exert compression on the ulnar nerve inside the ulnar tunnel. However, the pathophysiology is not limited to compression but also includes traction, friction, and elongation of the ulnar nerve. Similarly, the radial nerve inside the ulnar radial tunnel consisting of supinator brevis muscles, long carpus extensor, radialis brevis, and brachioradialis extensor, is exposed to both compression and traction, friction and elongation related to repetitive forced movements specific to certain occupations and professions. The professionals at high-risk for developing entrapment syndromes are those that frequently use hands or have prolonged strenuous grip such as tennis players, cyclists, athletes, boxers, baseball players, pneumatic hammer handlers, gardeners, drivers, or those with repetitive movements such as computer typists, conveyor workers, painters, musicians [16].

The known risk factors for entrapment syndromes are female gender (three times more common), smoking, old age, alcoholism, obesity, hysterectomy without oophorectomy, pregnancy, hypothyroidism, and recent menopause (up to one year) [17].

Depending on the severity of the carpal tunnel syndrome, several clinical forms are distinguished: mild, (characterized by paresthesias and nocturnal pain, absence or negation of clinical signs and tests), moderate (in which sensory and motor impairment coexist, positive clinical signs and tests being positive in most cases) and severe (in which muscle atrophy and reduced motor function dominate the clinical picture). A more advanced degree of severity can be considered a complication of the previous level.

The first cause of worsening of the carpal tunnel syndrome and of other entrapment syndromes is the absence of lifestyle changes and workplace activity. Therapeutic and post-therapeutic complications of carpal tunnel syndrome include resistance to treatment with local injectable NSAIDs and conservative prosthetic methods. The occurrence of these phenomena is a negative predictor of the success of the surgery. Recurrence of postoperative carpal tunnel syndrome due to inadequate or insufficient surgical techniques (they may also be secondary to an inadequate recovery program, such as continued professional overload) or intraoperative iatrogenic nerve damage, is possible.

Carpal tunnel syndrome, as well as the cubital tunnel syndrome or the radial tunnel syndrome, are frequently associated with other neuro-skeletal-muscular disorders of the hand, forearm, elbow, arm, shoulder, chest, back, and neck such as radiculopathy, tenosynovitis, tendinitis, and other entrapment syndromes (cervical radiculopathy, thoracic outlet syndrome) hence the proposed clinical model of "double crushing" syndrome. These associations and overlaps often create differential diagnosis problems, being numerous situations in which the late diagnosis of radial tunnel syndrome was preceded by surgery for other ipsilateral pathologies such as carpal tunnel syndrome, carpal tunnel syndrome with concomitant ipsilateral ulnar tunnel syndrome or de Quervain tenosynovitis [18]. Our patient at the 2015 MRI examination demonstrates the persistence of an inflammatory process in the tendons of the flexors of the fingers 2,3,4 with minimal fluid collection adjacent to the scaphoid bone affected by degenerative carpal disorders, but without obvious pain symptoms, probably due to lack of compression component mechanics.

The diagnosis of occupational neuro-musculoskeletal disorders involves both a primary clinical and a paraclinical approach. The positive anamnesis highlights changes in sensitivity and motor skills in which nocturnal pain is the most sensitive predictor of carpal tunnel syndrome (occur in 96%) of confirmed cases. The clinical diagnosis relies on the demonstration of the pain-paresthesia-dysfunction triad. In the case of the carpal tunnel syndrome that triad, it is highlighted by the Durkan, Tinel, and Phalen clinical tests. In the cubital tunnel syndrome by the Tinel test, the compression challenge test (practically a modified Durkan test) and the ulnar flexion test.

As for the radial tunnel syndrome the supination against resistance test, the extension against the resistance of the wrist test and the extension of the finger III against resistance test are most commonly used in practice (with the mention that the last two tests are used to differentiate the variant of posterior interosseous nerve syndrome from radial tunnel syndrome) (Table 1).

Other types of tests often used are the Semme-Weinstein discriminant sensory test and the static and dynamic "two-point" test. Recognition of the anatomical-physiological boundaries of the distribution of the nerve investigated by the hand diagram remains the most specific test (76%) for carpal tunnel syndrome.

Paraclinical tests do not increase the sensitivity and specificity of clinical trials but are often necessary to have an objective dg of occupational disease. They have a high indication for patients scheduled for surgery. Paraclinical tests consist of electromyogram (EMG) and nerve conduction studies. Although negative in about 20% of patients, they remain objective evidence of compressive neuropathy. Nervous conduction studies can be used for both sensory and motor studies. Any reduction in nerve velocity below 52 m/s is considered abnormal, and distal latencies are diagnostic (over 3.5 msec for the sensory component and over 4.5 msec for the motor) [19].

Paraclinical investigations include imaging examinations primarily. Contrary to carpal tunnel syndrome, it is much more challenging to locate the ulnar nerve lesion by electrodiagnostic and electromyographic studies because the ulnar nerve is more susceptible to entrapment and compression, especially in the wrist (ulnar tunnel syndrome - Guyon canal) but also due to overlapping clinical features of ulnar canal syndrome with brachial plexus lesions and C8-T1 cervical radiculopathy. In these complex situations, EMG remains the diagnostic test of choice [19].

Ultrasound examination and MRI can assess the ulnar nerve's appearance in the ulnar canal and its relationship with the surrounding soft structures (fascia, ligaments, muscles). Radiographs and CT exam allow the evaluation of bone structures; by color Doppler examination, the ulnar artery's patency in the ulnar tunnel can be verified [20].

The case presented by us seems to fall into this category of "double crushing syndrome" by highlighting the C5-C8-T1 cervical disc disease with associated radiculopathy and compression lesions at the ulnar level for the ulnar nerve and the dorsal-volar carpal level for the radial and median nerves. Postoperative scars with an inflammatory, fibrotic appearance may also contribute to the irritation of adjacent peripheral sensory nerve endings through a mechanism of neurogenic inflammation that potentially creates a new level of "crushing." The persistence in the same anatomical space of chronic tendonitis and de Quervain's tenosynovitis complicates the already quite intricate and complex local clinical picture. However, they seem to bring an additional argument in favor of the "multi-crushing syndrome" model. The apparent impairment of the right radial nerve sensory fibers at the level of the right forearm and the right radiocarpal joint and the complicating presence of an overlapping tenosynovitis de Quervain raised the clinical suspicion of radial tunnel syndrome. We consider it useful to mention it retrospectively in this discussion, even if it did not appear on the final list of diagnoses at the time of evaluation, being a diagnosis of exclusion that did not gather enough sufficient evidence.

Aspects related to the patient's occupation

The patient is a violinist in a prestigious symphony orchestra in the city of B. with a daily program structured on multiple rehearsals and alternating with performances and tours. From the onset of the neuro-osteoarticular disease, the patient did not interrupt the professional activity except for the periods of hospitalization and postoperative recovery within the legal limits allowed (2 weeks - 2 months). It is a well-established fact that violinists frequently suffer from diseases of the mandible, back, neck, shoulders, and hands with damage to both muscle and peripheral nerve [21].

The prevalence of musculoskeletal disorders caused by overload injuries varies between 65% and 93%. [22-24]. Nerve entrapment syndromes and their neuropathies caused by them, such as thoracic opening syndrome, occur in 20% of cases, and focal dystonia, characterized by occupational cramps and involuntary movements in 10% of cases [22]. The risk factors are intrinsic (age, sex, weight, physical strength, flexibility) and extrinsic that the artist can control (technique, frequency and intensity of artistic interpretation, rest duration, movement efficiency, ergonomics, posture, and repertoire difficulty). Changing the technique or instrument (a) intense preparation for performance (b), new and challenging repertoire (c), and prolonged performance periods without adequate rest (d) all lead to overload, static load, the stress of the musculoskeletal unit, peripheral nerves, and ligaments. Added to these is the element of interpretation of the respective passages, dependent on the training and the artist's personality and the artistic message she/he wants to convey. All these factors that lead to increased friction and local inflammation in the restricted and articular areas also play an essential role and the pathogenesis [25,26].

Diseases caused by repetitive movements, inappropriate postures, and stress, recognize as the primary mechanisms the wear and tear, the nerve compression, and focal dystonia. Pain is the main symptom, and among the most affected are performers on stringed instruments (violinists, cellists, harpists). Understanding the correct interpretation technique, position details, and posture specific to each instrument contributes to understanding the generation of associated morbid processes. As a primary posture stance, the dextrous violinist's body is in a semi-rigid sitting position with the head and neck flexed to the left. The upper train is rotated to the left relative to the lower train and associated with lumbar lordosis and compensatory thoracic rectification [21]. In connection with the occurrence of musculoskeletal disorders in musicians, some researchers and studies have shown that its posture and quality during artistic performance significantly affect the incidence of these diseases in musicians. [27]. All these movements and positions describe the usual position adopted by the interpreters of this instrument. The differences in the use of the right and left parts in the interpretation process make it necessary to present them separately below.

The left side

The left shoulder is elevated and held for a long time in this position of extreme external rotation coupled with the lowering of the mandible for fixing the instrument in the left supraclavicular fossa. This state of static contraction promotes sore throat, temporomandibular joint dysfunction, and thoracic opening syndrome.

The interpreter also tends to fix his gaze on his left hand, which accentuates the cervical tension and contributes to the mentioned problems. The wrist and forearm are most intensely used to produce notes and vibrato effects (a fast vibrating motion of the fingers on the violin strings with straining effect on all finger and wrist joints involved). The left elbow is in prolonged flexion and sustained supination. The wrist of the left hand is flexed on the neck of the violin and in ulnar deviation. This classic position favors the appearance of carpal tunnel syndrome and ulnar tunnel syndrome while promoting flexor carpi ulnaris tendonitis. Finally, the fingers of the left hand repeatedly and forcefully press the violin's strings to create the sounds desired by the performer, which generates over time injuries and calluses of the digital acral parts.

The right side

The right shoulder is in a state of sustained abduction and flexion for the bow's correct positioning in relation to the violin's body. Repetitive movements can cause rotator cuff tendonitis. Prolonged tremolo periods in some orchestral pieces can extend beyond an hour by restraining the cervical spine, the scapular-clavicular belt, and the flexors and extensors of the hand in a state of isometric contraction that allows the bow to move very quickly back and forth creating vibrations. Extended tremolos can lead to the overuse of the carpi radialis extensor and the carpi ulnaris flexor, which occasionally can compress the ulnar nerve in the Guyon canal. Rapid passages requiring fast changes on all strings of the instrument can overload and injure the rotator muscles of the shoulder, deltoid, and pectoralis [25].

The instrument's technical characteristics (violin) and the vibrations emitted by it depending on the musical style performed can influence the degree of musculoskeletal, vascular, and nervous damage. To these is added the tension of the bow. Depending on the style of music performed and the technique of the performer, the violin generates vibrations over a wide range of frequencies between 196 Hz and 4.4 kHz [28]. Vibrations transmitted through either the body of the violin, the strings and the bow raise the possibility of acquiring a "hand-arm vibration" syndrome (HAV Hand-Arm Vibrations syndrome) with well known neuro-musculoskeletal repercussions.

The organization of rehearsal sessions, their intensity and duration, the frequency of breaks, the ergonomic quality of the seats used, the position of the performer with regards to the conductor and the scores stand during both rehearsals and performances, the adequate length of the warm-up periods, the allowing for biomechanical training with feedback [29], the assistance with carrying heavy instruments, the comfort of transportation to and from rehearsals, shows or tournaments are all critical elements of careful management that can alleviate or, to the contrary, can increase the risk of occupational disease.

Socio-professional factors, interpersonal relationships with colleagues and bosses, professional satisfaction, motivation for performance, and environmental factors (temperature, ventilation, and insufficient light) can also affect instrumentalists' health.

Conclusions

The case presented by us above is an excellent example of upper limb neuro-musculoskeletal pathologies with the appearance of a clinical model of "double crush syndrome." The persistence and diversification of sensory and functional neuralgic clinical symptoms even in the presence of repeated invasive therapeutic measures raises many questions about the medical management strategy by ignoring the "double crush syndrome" model but perhaps especially about unacceptably long timing. of the patient's inclusion from the first diagnosis moment (2005-2009) in the form of the occupational disease with the radical change of the occupational exposure paradigm and with the potential for a profound change in the evolution of the subsequent morbid process [30,31].

Acknowledgments and Permissions

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The patient has provided written consent to the written and photo content of this article. In the writing and publishing process, we exercised the necessary caution to preserve sensitive data's privacy.

References

1. Upton AR, McComas AJ. The double crush in nerve entrapment syndromes. Lancet 1973;2:359–62.
2. Joseph M. Bellapianta et al.: Chapter 21 - HAND PAIN, Current Therapy in Pain, 2009, Pages 156-167, ISBN 9781416048367.
3. G.D. Lister, R.B. Belsole, H.E. Kleinert: The radial tunnel syndrome, The Journal of Hand Surgery, Volume 4, Issue 1, 1979, Pages 52-59.
4. YC Loh et al.: A new clinical test for radial tunnel syndrome—the Rule-of-Nine test: A cadaveric study, Journal of Orthopaedic Surgery 2004;12(1):83–86
5. L.B. Dahlin et al.: The neuron and its response to peripheral nerve compression, Journal of Hand Surgery (British Volume, 1990) 1SB: 5-10
6. L.C. Hurst, D. Weissberg, R.E. Carroll: The relationship of the double crush to carpal tunnel syndrome (an analysis of 1,000 cases of carpal tunnel syndrome), J. Hand Surg. [Br], 10 (1985), pp. 202-204
7. Brent S Russell: Carpal tunnel syndrome and the "double crush" hypothesis: a review and implications for chiropractic, Chiropractic & Osteopathy 2008, 16:2
8. A.L. Osterman:The Double Crush Syndrome. Orthop.Clin.North. Am.1988;19(1), pg.147-55.
9. Galarza M, Gazzeri R, Gazzeri G, Zuccarello M, Taha J. Cubital tunnel surgery in patients with cervical radiculopathy: double crush syndrome?. Neurosurg Rev. 2009; 32(4) :471-478.
10. H. Baba et al: Changes in peripheral nerve fibres distal to a constriction, Journal of the Neurological Sciences, 1982, 54:197-208
11. Koichi Nemoto et al.: An experimental study on the "double crush" hypothesis, The Journal of HAND SURGERY, vol. 12A, No. 4 July 1987, pg.552-559
12. A.O. NARAKAS: The role of thoracic outlet syndrome in the double crush syndrome, Ann Hand Surg, 1990, 9, n° 5, 331-340.
13. Kwon HK, Hwang M, Yoon DW. Frequency and severity of carpal tunnel syndrome according to level of cervical radiculopathy: double crush syndrome?. Clin Neurophysiol. 2006;117(6):1256-1259.
14. Chakravarthy Marx, S., Kumar, P., Dhalapathy, S. et al. Distribution of sympathetic fiber areas of radial nerve in the forearm: an immunohistochemical study in cadavers. Surg Radiol Anat 32, 865–871.
15. Kane et al.: Multifocal Neuropathy: Expanding the Scope of Double Crush Syndrome. J Hand Surg Am. 2016;41(12):1171-1175.
16. Gautam J. Desai DO et al.: Chapter 70 - Carpal Tunnel Syndrome, Integrative Medicine (Fourth Edition), Elsevier, 2018, Pages 697-706. e2, ISBN 9780323358682
17. Joseph E. Pizzorno et al.:15 - Carpal tunnel syndrome, The Clinician's Handbook of Natural Medicine (Third Edition), Churchill Livingstone, 2016, Pages 180-187, ISBN 9780702055140
18. Sotereanos DG, Varitimidis SE, Giannakopoulos PN, Westkaemper JG. Results of surgical treatment for radial tunnel syndrome. J Hand Surg Am. 1999;24(3):566-570.
19. David C. Preston, Barbara E. Shapiro: David C. Preston, Barbara E. Shapiro: 29 - Radiculopathy Pages 448-467, 30 - Brachial Plexopathy, Pages 468-486, 31 - Proximal Neuropathies of the Shoulder and Arm, Pages 487-500, Electromyography and Neuromuscular Disorders 2013, ISBN 978-1-4557-2672-1
20. Mary G. Hochman MD: II/14 Entrapment Syndromes Pages 239-263, Imaging of Arthritis and Metabolic Bone Disease, 2009, ISBN 9780323041775
21. Geraldo Fabiano de Souza Moraes et al.: Musculoskeletal disorders in professional violinists and violists. Systematic review, Acta Ortop Bras. 2012;20(1): 43-7
22. Richard A. Hoppmann and Nichols A. Patrone: A review of musculoskeletal problems in instrumental muscians. Seminars in Arthritis and Rheumatism, Vol.19, No.2 (October), 1988, pp. 117-126
23. Peter Bragge, Andrea Bialocerkowski, Joan McMeeken, A systematic review of prevalence and risk factors associated with playing-related musculoskeletal disorders in pianists, Occupational Medicine, Volume 56, Issue 1, January 2006, Pages 28–38,
24. Zaza C. Playing-related musculoskeletal disorders in musicians: a systematic review of incidence and prevalence. CMAJ. 1998;158(8):1019-1025.
25. John Chong et al: Occupational Health Problems of Muscians. Can Fam Physician 1989;35:2341-2348
26. V.A.E. Baadjou et al.: Systematic review: risk factors for musculoskeletal disorders in musicians. Occupational Medicine 2016;66:614–622
27. Patricia Blanco-Pineiro et al.: Musicians, postural quality and musculoskeletal health: A literature's review. Journal of Bodywork & Movement Therapies (2017) 21, 157e172
28. Colin E. Gough : A violin shell model: Vibrational modes and acoustics. Journal.Acoust.Soc.Am.137(3), March2015, pp. 1210-1225
29. Pascarelli EF, Hsu YP. Understanding work-related upper extremity disorders: clinical findings in 485 computer users, musicians, and others. J Occup Rehabil. 2001 Mar;11(1) 1-21.
30. Nica Sarah Adriana: Recuperarea mainii posttraumatice, Patologia aparatului locomotor,, Vol. I- 2005, cap IV.27.3
31. Constantinovici Mariana Isabela: Mana disfunctionala posttraumatica si reumatismala - Evaluare si recuperare, Ed. Universitara ,,Carol Davila,, Bucuresti 2017.