Case Report

Devastating ischemic dimelic neuropathy after plastic zip tie handcuffs; message for security agencies

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ABSTRACT

Ischemic monomelic neuropathy (IMN) is an infrequently recognized type of ischemic neuropathy produced by the shunting of blood away from, or the acute non compressive occlusion of, a major proximal limb artery. IMN consists of multiple mononeuropathies with axonal-loss that develop acutely and simultaneously in the distal portion of a limb. Ischemic neuropathies in a single limb are well-known following compression (casts or tourniquet use), proximal vascular procedures like AV fistula formation, thoracic outlet syndrome, trauma, and thromboembolism. We report the first case of ischemic neuropathies of both upper limbs caused by plastic zip ties handcuffs. We call it “ischemic dimelic neuropathy (IDN)”.

This case highlights and increases awareness among physicians and security agencies to recognize ischemic dimelic neuropathy (IDN) early, take measures to prevent this rapidly developing neuropathy, and discourage the use of plastic handcuffs for suspects/accused in their arrest process or inside correctional places.

1. Introduction and importance

The term “ischemic monomelic neuropathy” IMN was introduced in 1983 by Wilbourn. The term refers to the combination of ischemia and neuropathy in a single limb [1]. This type of ischemic neuropathy is caused by the shunting of blood away from, or the acute non compressive occlusion of, a major proximal limb artery. IMN consists of multiple axonal-loss mononeuropathies that develop acutely and simultaneously in the distal portion of a limb [1].

Ischemic neuropathies are a well-known entity following compression (casts or tourniquet use) predominantly in one of the upper limbs. Similar injuries are also reported in the literature regarding the use of force by security agencies [2].

One of the devastating ischemic nerve injury after cuffing hands from behind with plastic zip handcuffs is not frequently described despite their frequent usage around the world by military and nonmilitary armed forces. This is especially increasing in number in countries that are war-torn or coping with terrorism after 9/11.

We report a case of ischemic neuropathies caused by plastic zip ties handcuffs. The case is reported in line with the SCARE 2020 criteria [3]. We report this as “ischemic dimelic neuropathies IDN” and not as “monomelic” due to the involvement of both upper limbs.

2. Case presentation

A 22 years old male with no prior co-morbidities presented with complaint of numbness and weakness of both upper extremities for 2 weeks. He was arrested and then released by law enforcement agency as a suspect before this presentation. At the time of arrest his hands were tied up with plastic zip handcuffs from behind (Fig. 1). The patient developed numbness soon after tying of the bilateral arms and forearm probably in minutes. His hands and forearms remained cuffed for 36 hours. He was beaten up in different positions including notorious “hobble restraint” (prone position with arms and legs restrained behind the back) multiple times. After this period when zip ties were cut he was unable to flex his forearms and move his hand muscles properly. The patient presented to the neurophysiology lab 2 weeks after the release of his hands from these handcuffs while his symptoms remained the same. His review of systems was otherwise normal. His past medical and
surgical history was unremarkable. He denied taking any medication, drugs, or alcohol. His family history was unremarkable and did not report any genetic/hereditary disease.

General Physical examination revealed atrophied distal hand muscles. Finger flexion and abduction had Medical Research Council (MRC) 2/5 power while forearm flexion was 3/5 and extension 4/5. Deep tendon jerks were absent in both upper limbs distally. There was decreased pin prick in distal forearm and hand dermatomes. Glasgow Coma Scale was 15/15. Cranial nerves were intact. The rest of the physical examinations including the cardiovascular, gastrointestinal, and respiratory system examination were unremarkable.

3. Investigations

Electrodiagnostic data revealed asymmetric low motor amplitudes of bilateral musculocutaneous and radial nerves while non-recordable right median and bilateral ulnar nerves, distal latencies and borderline slow conduction velocities. Conduction blocks were noted in the left median and radial motor nerves (Table 1). Sensory potentials of the above nerves were non-recordable except for the left median and medial antebrachial sensory nerves (Table 2).

In EMG, there were either absent or scant motor units in first dorsal interossei, abductor pollicis brevis, and extensor indicis propius muscles. There was also evidence of active axon loss changes in the above muscles bilaterally. In two of the proximal muscles pronator teres and biceps brachii, there were rapid firing rate motor units with normal unit configuration and no evidence of active denervation potentials.

4. Differentials

Differentials at the time of examinations included brachial plexopathies, traumatic nerve injuries, and possible prior congenital or hereditary neuropathies that were aggravated by this incident. The possibility of later was unlikely as there was no past medical history of any neuropathies before this incident. He had no history of avulsion or penetrating injury to the brachial plexus. Vascular steel syndrome was less likely and it was ruled out based on the absence of skin or muscle ischemia. However, the patient was lost to follow up.

5. Clinical discussion

Causes of Ischemic monomelic neuropathy include proximal vascular procedures like AV fistula formation, thoracic outlet syndrome, trauma, and thromboembolism [4]. Ischemic monomelic neuropathy is an uncommon complication of arteriovenous (AV) fistula for hemodialysis [5]. The etiology is considered an ischemic insult to the proximal limb, which results in multiple axonal loss mononeuropathies [6,7]. After placement of an AV fistula, there can be shunting of arterial blood away from the distal extremity resulting in damage to distal nerve fibers. This is manifested by acute neurologic symptoms but ischemia is insufficient to cause muscle or skin necrosis.

Nerves are prone to ischemia (sensory fibers more than the motor), owing to the lack of a collateral supply. This is probably due to the nerve’s lower threshold for ischemia in comparison to the skin or muscle [4]. Symptoms of IMN include acute pain, paresthesia, and numbness in the distribution of radial, median and ulnar nerves accompanied by diffuse motor weakness. These symptoms are severe enough to cause paralysis such as wrist drop [8].

Electrodiagnostic studies are helpful in diagnosis where clinical findings are equivocal [9]. Nerve conduction studies demonstrate axonal loss, and reduced motor and sensory nerve conduction velocities of median, radial, and ulnar nerves [1]. Electromyography can reveal acute distal denervation of all upper limb nerves. Our case has similar neurophysiologic findings as described earlier in the literature due to ischemia.

Significant neurological morbidities are described with restraints tools used by the law enforcement forces. One such notorious tools are plastic zip handcuffs used frequently in an emergency situation such as raid or custody. Although vast majority of handcuffs do not cause significant morbidity or mortality, severe peripheral nerve injuries or focal neuropathies were seen by Chariot et al. in subjects who were handcuffed behind their back [10]. Such injuries were more significant in the longer duration of handcuff application with a mean time of 3.7 hours. In our case situation was graver as duration of restraint was 36 hours. Moreover handcuffing behind the back in our patient further extended ischemic injury towards proximal nerves. We hypothesize that the involvement of proximal nerves was due to extreme posterior rotation of
the forearm and shoulder that caused compression of the Axillary artery, especially its 1st and 2nd part and subsequent brachial artery. As the patient’s hands were tied from the back and he was beaten in different positions including notorious hobble restraint (prone position with arms and legs restrained behind the back), this is likely that he has suffered from more severe compression in proximal regions rather than just tying. In a study done by Lorin dela Grandmaison et al. [11]. at least 22 cases of neuropathies in connection with the application of excessively tight handcuffs were observed. Ischemia was probably the sole component of all pathology involved in these neuropathies. Unlike IMN we name our case as Ischemic dimelic neuropathy IDN as an element of ischemia existed simultaneously in both upper limbs following this tight handcuffing.

Contrary to the previous studies, our patient had prolonged detention of handcuffing from behind up to 36 hours. Moreover this case is different as there is the involvement of proximal nerves along with distal nerves.

Plastic zip type handcuffs produce rapid and severe neuropathies ranging from compression neuropathies (neuropraxia) to secondary axonal loss (axonotmesis) as compared to other means of handcuffs. This can lead to temporary sensory loss or long lasting handicap conditions for the patients. Literature often describes more rapid and severe injury in victims of police custody who had used alcohol or were in a delirium state at the time of arrest or during the custody period [2]. In our case, there was no such evidence of substance abuse, loss of consciousness or severe toxic metabolic condition of the victim. He did not complain of any symptoms in the past.

Taking our patient’s full history, course of events, development of symptoms, neurological examination, and electrophysiological evidence we conclude that all these abnormalities were solely due to tight plastic zip ties.

6. Conclusion

Security agencies need to exercise caution while handcuffing suspects, and avoid the use of plastic zip ties. The use of plastic zip ties especially for prolonged durations can result in devastating ischemic neuropathy.

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Author contribution

TH and AW performed data collection; AW performed the NCS and EMG tests; TH and AW drafted the manuscript, critically reviewed, and approved the final manuscript. Fig. 1 drawn by Ahmad Wali.

Research registration

N/A.

Guarantor

Taimoor Hussain and Ahmed Wali accept full responsibility for the work and/or the conduct of the study, had access to the data, and controlled the decision to publish.

Consent

Written informed consent was obtained from the patient for publication of this case report and accompanying images. A copy of the written consent is available for review by the Editor-in-Chief of this

| Table 1 | Motor nerve conduction studies. |
|---------|-------------------------------|
| NERVE (REC. SITE) | STIMULUS SITE | DISTANCE (cm) | LATENCY (ms) | AMPLITUDE (mV) | NCV (m/s) | F.LAT. (ms) |
| MEDIAN(APB) | Wrist | 5.0 | NR | 2.9 | NR | 5.7 | NR | NR |
| | Elbow | 24.0 | NR | 8.4 | NR | 0.1 | NR | 43.6 |
| ULNAR(ADQ) | Wrist | - | NR | NR | NR | NR | NR | NR |
| | Distal to Elbow | - | NR | NR | NR | NR | NR | NR |
| RADIAL(EIP) | EDC | 8.0 | NR | 3.0 | 2.5 | 2.7 | 4.0 | |
| MUSCULO -CUTANEOUS | AXILLA | 16.0 | NR | 4.0 | 4.1 | 0.2 | 1.0 | 40.0 |
| | ERB’S | |

Nerve conduction findings of motor nerves of upper limbs showing asymmetric low motor amplitudes (non-recordable or very low). Left sided nerves are worse than right side. There is also evidence of focal conduction block in left median nerve.

Abbreviations: NR: Non recordable, APB: Abductor pollicis brevis, ADQ: Abductor digiti quinti, EIP: Extensor indicis proprius, EDC: Extensor digitorum communis.

| Table 2 | Sensory nerve conduction studies. |
|---------|-------------------------------|
| NERVE | STIMULUS SITE | RECSITE | DISTANCE (cm) | LATENCY (ms) | AMPLITUDE (uV) | NCV (m/s) |
| MEDIAN | Wrist | F2 | 14.0 | NR | 2.9 | NR | 18.8 | NR | 48.2 |
| ULNAR | Wrist | F5 | 12.0 | NR | NR | NR | NR | NR | NR |
| DUC | Wrist | DOH | 8.0 | NR | NR | NR | NR | NR | NR |
| RADIAL | F.ARM | S.BOXY | - | NR | NR | NR | NR | NR | NR |
| M.A.B | Elbow | F.ARM | 7.0 | NR | 1.5 | NR | 15.4 | NR | 46.7 |
| L.A.B | Elbow | F.ARM | 7.0 | DA | NR | DA | NR | DA | NR |

Nerve conduction findings of sensory nerves of upper limbs showing non-recordable sensory potentials of almost all nerves except left median and medial antebrachial sensory nerves.

Abbreviations: DUC: Dorsal ulnar cutaneous, MAB: Medial antebrachial sensory nerve, LAB: Lateral antebrachial sensory nerve, NR: Non recordable, DA: Difficult to assess, F: Finger, S.BOXY: Snuff box, F.ARM: Forearm, DOH: Dorsum of hand, REC: RECRUITMENT
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Declaration of competing interest
The authors declare they have no conflict of interest.

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