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Phantom Phenomena (Phantom Arm) Following Cervical Root Avulsion

Effect of Dorsal Root Entry Zone Thermocoagulation

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Summary. We report on nine male patients with cervical root avulsions and brachial plexus injuries following traffic accidents. These non-amputees (mean age 33.7 years) had a phantom arm beside the paralysed arm. Cervical root avulsions were demonstrated either by myelography or surgically. Mostly the roots C5–Th1 were affected. Eight of the nine patients had Horner's syndrome on the side of the root avulsion. The phantom arm appeared immediately after the accident, except in one patient who was symptom-free for 2 weeks. In two cases the phantom arm disappeared spontaneously. Four patients underwent a DREZ lesion. After surgery the phantom arm disappeared, and three of the patients became pain-free, while one patient experienced pain relief of 20% to 50%. Reviewing the literature it is assumed that phantom limb following injury to the brachial plexus indicates cervical root avulsion. In such cases Horner's syndrome is a good indication for lower cervical root avulsion (C8–Th2).

Key words: Phantom arm – Non-amputees – Cervical root avulsion – Brachial plexus injury – DREZ lesion

Introduction

The phantom limb of amputees has been a well-known phenomenon since the first description by Mitchell in 1871, who was the first to use the term "phantom limb" [11–13]. Previously Ambroise Paré in 1545 had noticed the phenomenon of phantom sensations, and one can assume the existence of phantom phenomena ever since patients have survived limb amputations [20]. The cases reported here do not concern this classical phantom limb but the more unusual phantom phenomena when the limb—especially the arm—is preserved and a "second limb" experienced.

Phantom sensations can be replaced by a torturing pain. Narakas [14] noted severe pain in 40% of patients with avulsions and supraclavicular ruptures, and in 35% of patients with extraforaminal lesions of the spinal nerves and trunk. These excruciating pain syndromes in non-amputees are comparable to the pain following limb amputation. From clinical and experimental observations a central origin of the pain with hypersensitivity of neuronal pools in the dorsal root entry zone (DREZ) can be envisaged. According to this theory Nashold [15] introduced the technique of thermocoagulation of the substantia gelatinosa and reported good results.

For the past 3 years we have seen all patients with phantom limbs following severe injuries to the brachial plexus or cervical root avulsions, a total of nine patients.

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Patients and Results

Table 1 shows the data of our patients. There were no females in the group which consisted of victims of traffic accidents, usually involving motorcycles or motor-assisted bicycles. Two patients were pedestrians and the victims of car accidents. One patient, a car driver, was not wearing a safety belt and was catapulted against a tree, striking his left shoulder. The youngest patient was 18, and the oldest 62 years old, with the mean age 33.7 years.

Cervical root avulsion was demonstrated either by myelography or during surgery. Mostly the roots C5–Th1 were affected. Only in one patient (No. 3) was the Th1 root spared and this was the unique case without Horner's syndrome. The remaining eight cases presented Horner's syndrome on the side of root avulsion.

Table 2 shows the root avulsions, demonstrated by myelography. In two cases an ipsilateral paralysis of the diaphragm indicated involvement of the C4 and C5 root because the phrenic nerve arises chiefly from the fourth and fifth (sometimes from the third) cervical nerve [6, 19].

Table 3 shows the root avulsions demonstrated during surgery. All patients had both root avulsions and severe brachial plexus injury. A good indication of plexus injury in the early stage was hypohydrosis. All six patients who came to hospital immediately after their accident and underwent neurological examination during the first days showed hypo- or anhydrosis of the paralysed arm and hand. Later the plexus involvement was evident clinically and electromyographically.

Accompanying Injuries

Six of the nine patients had minor head trauma. Three patients had no head injury because they had been wearing motorcycle crash helmets. The accompanying injuries are shown in Table 4.

Table 1

Patient	Age (years)	Accident	Injury	Phantom	Operation
1. G.E.	45	Car 5.6.1977	C5–Th1 left Horner left	Immediately until 1983 (second hand, forearm)	Plexus explor. DREZ lesion
2. H.B.	24	Motor bike 20.7.1965	C5–Th1 left Horner left	Immediately until 1982 (second forearm, hand)	Plexur explor. DREZ lesion
3. R.G.	28	Motor bike 9.4.1958	C5–C8 left (no Horner!)	Immediately until 1959 (second forearm, hand)	Plexus explor. DCS
4. B.H.	59	Pedestrian 7.10.1979	C6–Th1 right (Horner right)	Immediately until 1983 (second forearm, hand)	DREZ lesion
5. W.C.	20	Motorcycle 5.8.1983	C4–Th1 right (Horner right)	Immediately until 3 weeks (second forearm, hand)	∅
6. D.H.	28	Motorcycle 19.8.1982	C8–Th1 left (Horner left)	2 weeks after accident, until October 1982 (second hand)	DREZ lesion
7. B.K.	62	Pedestrian 10.11.1981	C5–Th1 right (Horner right)	Immediately, until December 1981 (second forearm, hand)	Nashold
8. Sch.M.	18	Motor bike 29.7.1982	C6–Th1 left (Horner left)	Immediately, second hand	Plexus explor.
9. Sch.A.	20	Motorcycle	C5–Th1 right (Horner right)	Immediately, second hand	Plexus explor.

Table 2. Root avulsions demonstrated by myelography

Patient no.	Avulsed roots
4. (B.H.)	C6–Th1 right
5. (W.C.)	Th1 right
6. (D.H.)	C6–Th1 left
7. (B.K.)	C8, Th1 right
8. (Sch.M.)	C6–Th1 left (probably C4/C5: diaphragm palsy left)

Table 3. Root avulsions demonstrated by operation

Patient no.	Avulsed root
1. (G.E.)	C6–Th2 left
2. (H.B.)	C5–Th1 left (diaphragm paralysis left)
3. (R.G.)	C5–C8 left
9. (Sch.A.)	C6–Th1 right

Table 4

Patient no.	Accompanying injuries
1. (G.E.)	Fractured ribs, left knee injury
2. (H.B.)	Left forearm fracture, contusion of the left hand
3. (R.G.)	Left humeral fracture, left and right femoral fractures
4. (B.H.)	Fracture of the right foot, injury of the right knee, fracture of the 7th cervical vertebra
5. (W.C.)	Fracture of the right lower jaw, injury to the right subclavian artery
6. (D.H.)	Rupture of the spleen, injury of the left knee, incomplete rupture of the left tendon of the quadriceps
7. (B.K.)	Right humeral fracture, contusion of the right shank
8. (Sch.M.)	Left forearm fracture, left femoral fracture, dislocation of the left foot
9. (Sch.A.)	Right scapula fracture, fracture of the right distal radius, right femoral fracture

Phantom Sensations

A) Form of the Phantom. The phantom-form was adequate to the paralysed limb. Six of the nine patients reported a second forearm with hand. An isolated, second hand was reported by two patients, and a complete second arm by remainder. The distal parts of the upper extremity, especially the fingers, were experienced most distinctly; the sensation of a second forearm was not as clear as that of a second hand.

B) Time of Manifestation and Duration of the Phantom. In eight of the nine patients the phantom appeared immediately after the accident. In one patient there was an interval of 2 weeks. Duration of the phantom feeling varied considerably: in one case it disappeared after 3 weeks, in a second case after 6 weeks. In the remaining cases the phantom existed for between 1 year and a maximum of 17 years. Among the cases undergoing a DREZ operation the phantom disappeared post-operatively and had not reappeared up to the last follow-up examination in October 1983.

C) Location of the Phantom Limb. All patients described the phantom arm in a position beside the paralysed arm. The phantom hand was reported to be at a 45° position to the paralysed hand, and the phantom forearm was also located at an angle $< 90°$ to the forearm. In one case the phantom forearm was in a position of 45° upward to the paralysed arm. All patients reported that they could not bring the phantom limb to exactly the same position as the paralysed arm. If they attempted to put the paralysed arm into the position of the phantom, the phantom turned aside or was experienced as something underneath. All patients reported inability to move the phantom limb ("paralysed phantom"). Especially in the morning immediately after awakening, a spontaneous movement of the phantom was experienced by three patients. These persons had difficulties in differentiating a change in the intensity of the phantom phenomenon from a spontaneous movement.

D) "Telescope Phenomenon". Only two of the nine patients reported a shortening of the phantom limb. The typical changes in length with movement of fingers or toes from distal to proximal, common in amputees, were not reported in this group. However, six among the nine patients reported swelling of the forearm or hand if the extremity was in hanging position.

E) Phantom Pain. Five of the nine patients had no pain in the early phase after injury in the paralysed arm or in the phantom. This painless time existed for a maximum of 2 months. Thereafter all patients had severe pain. They could not specify whether the pain was located in the phantom or in the paralysed arm. The main points of pain sensations were the distal parts of the extremities, i.e. thumb, other fingers, ulnar part of the forearm or the whole hand.

F) Effect of Thermocoagulation in the DREZ. Among the nine patients four underwent an operation of the DREZ at the level of the middle and lower cervical spinal cord. In these four cases there were avulsions of 4–5 cervical nerve roots (Table 3).

Operative Technique. A hemi-laminectomy was performed. Incision of the dura was made over the root avulsions and pseudo-meningoceles. Microscopically thickened arachnoidea, focal atrophies, scars, pathological vascularisation and rarefication of the neighbouring intact roots were seen. In the zone of the avulsed roots as well as cranially a high frequency coagulation lesion was made at 2 mm intervals along the intermediolateral sulcus. The non-isolated tip of the electrode was introduced 2 mm.

Results

After surgery the four patients felt pain relief, and three had remained completely pain-free until the last follow-up examination in October 1983. One patient reported pain relief of between 20% and 50%. All patients reported that the phantom arm disappeared after surgery. The follow-up was between 9 months and 2 years.

Discussion

There are only a few reports on phantom limbs in non-amputees in the literature. In 1929 Mayer-Groß [8] reported a case of phantom arm after plexus rupture. He described a young man who had had an accident with his motorcycle in 1927, and Horner's syndrome was evident on the left side. The operative exploration revealed a complete rupture of the brachial plexus. The description of Horner's syndrome points to an avulsion of the Th1 root because Horner's syndrome is a good indication of an avulsion of this lower root. In 1941 Hasenjäger and Pötzl [5] reported on a case of phantom arm in plexus paralysis, and they were the first to use the term "phantom arm" in plexus paralysis. In their case Horner's syndrome was not noted, and a myelography was not performed. In 1941 Riddoch [18] reported on an 18-year-old boy with a phantom following severe brachial plexus injury, although he did not mention Horner's syndrome or a myelography. In recent years Reisner [17] reported on two cases of phantom arm in plexus paralysis. In both cases there was a cervical root avulsion, which was demonstrated either myelographically or by operation. The roots C8 and Th1 were avulsed, in the latter case with ipsilateral Horner's syndrome. A review of the cases reported in the literature reveals that a phantom arm in isolated plexus paralysis without any root avulsion had hitherto not been demonstrated. Cases involving myelography or surgery always had both plexus injury and root avulsion. The mention of Horner's syndrome in case reports is a relatively reliable indication of lower root avulsion (Th1). Theoretically Horner's syndrome could occur without root avulsion, i.e. in cases with isolated rupture of the connective fibers to the sympathetic trunk, although in clinical practice this seems very unlikely.

The cases reported here confirm the clinical experience that in patients with Horner's syndrome a lower root avulsion can be expected. A phantom phenomenon after dissection of the dorsal root has previously been reported by Gagel (citated by Hasenjäger and Pötzl [5]. While phantom phenomena in cases with spinal cord injury are quite common [1–3], they are a rarity in other diseases of the spinal cord. There are only few reports on phantom sensations in multiple sclerosis [7].

Discussing the question of phantom phenomena in isolated brachial plexus injury without root avulsion some observations from anaesthetists are of special interest. During regional anaesthesia (peridural and plexus anaesthesia) phantom sensations are quite common. Mihic and Binkert [9, 10] reported phantom sensations of upper and/or lower extremities in 63% of patients following brachial plexus anaesthesia, in 18% following peridural anaesthesia and in 40% of patients following spinal anaesthesia. Bromage and Melzack [4] reported on phantom phenomena in 85% of their cases following brachial plexus anaesthesia. In these cases the phantom appears immediately after the local anaesthesia. There seems to be a relationship between the intensity of anaesthesia and the manifestation of the phantom limb: with increasing intensity of anaesthesia the phantom becomes more pronounced [10]. In these cases there is little doubt about the phantom limb phenomena in isolated brachial plexus irritation. However, after isolated brachial plexus injury phantom limb phenomena has not yet been proved. This study together with other published case reports suggests that a phantom limb following brachial plexus injury indicates an additional cervical root avulsion.

Elimination of the phantom limb and pain relief following thermocoagulation in the DREZ of the cervical spinal cord suggests that in the neuronal pool of the posterior horn following de-afferentation trans-synaptic processes occur, triggering the pain centrally and producing the development of phantom phenomena.

However, there is at present no definite answer regarding the mechanisms of phantom sensations.

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