chemists and is used mainly as a rodenticide (rat poison). We report an unusual case of barium carbonate poisoning. The nerve and muscle electrophysiological studies are reported for the first time in barium carbonate intoxication.

A 19 year old boy presented to a hospital emergency department with sudden onset tetraplegia. He was referred to our centre as a case of Guillian-Barré syndrome. The patient presented with tingling in the right upper arm, which was immediately followed by weakness in all four limbs. The weakness progressed and involved trunk muscles also within a few minutes. There was no history suggestive of bulbar or facial nerve involvement.

On examination, higher mental functions, cranial nerves, and sensory and cerebellar examination were normal. Examination of the motor system showed a power of 0/5 globally. No deep tendon reflex could be elicited. Surprisingly, with complete areflexic paralysis there was increased tone in the lower limbs. A diagnosis of Guillian-Barré syndrome was considered, but there were some pointers against this diagnosis. The onset and progression to complete tetraplegia was very rapid and the weakness started from the upper limbs followed by that of the lower limbs. Increased tone in the lower limbs was also not consistent with the diagnosis of Guillian-Barré syndrome.

Routine blood investigations at the time of admission, including serum electrolytes, were normal. Nerve conduction study showed normal distal latency of the compound muscle action potential and motor nerve conduction. Amplitude of the compound muscle action potential was low on proximal and distal stimulation. No conduction block, dispersion of compound muscle action potential, or F wave response was recordable. Sensory conduction studies on median and ulnar nerves at both sides of the body were normal for distal latency and amplitude of sensory nerve action potential. No H reflex was recordable on stimulation of posterior tibial nerves on both sides. The patient now disclosed that he had accidentally consumed barium carbonate (15 g) on the day before admission. He ingested barium salt by mistaking it for dieting food given to him by a slimming centre. Ingestion was followed immediately by profuse vomiting. One hour later, the patient had watery diarrhoea. Four hours later he was taken to hospital where his stomach was washed out with magnesium sulphate solution. Blood investigations repeated 8 hours after admission showed normal blood counts, blood gas analysis, and renal and liver function tests. Serum potassium was 2.8 mmol/l and sodium was 140 mmol/l. An ECG showed prominent U waves. Based on available history and investigations, a diagnosis of barium carbonate induced hypokalaemic periodic paralysis was considered. The patient was moved to the intensive care unit and monitored for arrhythmias. He was started on intravenous potassium. On day 2, the patient had completely recovered clinically (power 5/5). Serum potassium was normal. Nerve conduction studies were performed as on day 1 with similar results except that the amplitude of compound muscle action potentials were in the normal range. The F waves and H-reflexes were still unrecordable. Electromyography was carried out with concentric needles in the biceps, deltoid, and quadriceps. It showed no abnormal insertional or spontaneous activity and motor unit action

potentials were normal in amplitude and duration. The recruitment pattern was reduced. Visual evoked potential, EEG, and brain stem evoked potential were all normal. Nerve conduction velocity and EMG were repeated on day 7 and were normal in all aspects.

Most patients with barium intoxication have gastrointestinal and cardiac involvement with tetraplegia. Barium carbonate is a rare cause of hypokalaemic periodic paralysis.¹ Diarrhoea and arrhythmias are due to direct stimulatory action of barium ions on smooth and cardiac muscles.² Heart failure and hypertension may occur in a few cases. Barium blocks the potassium channels and thus potassium efflux from the muscle is reduced whereas the sodium-potassium pump is intact. This causes increased potassium in the muscle and decreased resting membrane potential.³ Barium acts mainly at the neuromuscular junction by this mechanism.⁴ The fatal dose of barium carbonate is 0.8 g and death occurs within 2–12 hours.⁴

There is only one report of an EMG study done in four patients with paralysis because of barium carbonate poisoning. It was done within 1 week of admission and did not show any abnormality.⁴ In our case nerve conduction velocity studies and EMG were done on the first day and were sequentially repeated. Interpreting the nerve conduction velocity studies of day 1—namely, low amplitude of compound muscle action potentials—would indicate axonal neuropathy but similar findings can be found in profound muscle weakness because of neuromuscular junction blockade or myopathy. Loss of F waves and H reflexes on day 1 can be explained by the presence of lower amplitudes of compound muscle action potentials on distal nerve stimulation. Loss of F waves and H reflexes with normal distal nerve conduction velocity is suggestive of proximal demyelination or dysfunction at the spinal cord level. Loss of H reflexes and the F response has not been reported previously in patients with hypokalaemic periodic paralysis. As H reflex latency depends on several factors including the central delay in the cord involving conduction, synaptic transmission, and activation of anterior horn cells, any of these processes might be involved in barium carbonate poisoning. The exact mechanism for their absence is still unclear. These responses reverted back to normal on day 7. The concentric needle EMG study on the second day showed a reduced recruitment pattern which is found in neuropathies but has also been reported in hypokalaemic periodic paralysis.⁵

In most cases of barium ingestion the recovery from weakness occurs rapidly and uneventfully.⁴ Oral magnesium sulphate or sodium sulphate precipitate barium in the gut and thus reduce absorption. Large amounts of intravenous potassium are needed to restore the pump electrogenesis and to displace barium from potassium channels.¹ Hypertension caused by barium cannot be reversed by this treatment. Haemodialysis is a useful therapeutic adjuvant in severe barium carbonate poisoning. Ventilatory support may be required due to respiratory muscle involvement.⁴

In summary, this is the first electrophysiological study done on day 1 in a case of barium carbonate poisoning with paralysis. Previously involvement of neuromuscular junctions has been considered as a cause for weakness. In our study, we found that barium

acted at more than one level—that is, muscles, proximal segments of the reflex arc, and probably γ efferents as the tone was increased.

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- 1 Stedwell RE, Allen KM, Binder LS. Hypokalaemic paralysis: review of etiologies, pathophysiology, presentation and therapy. *Am J Emerg Med* 1992;10:143–8.
- 2 Gosselin RE, Smith RP, Hodge HC, et al. *Clinical toxicology of commercial products*, 5th ed. Baltimore: Williams and Wilkins, 1984;3:61–2.
- 3 Layzer RB. Periodic paralysis and the sodium-potassium pump. *Ann Neurol* 1982;11:5437–52.
- 4 Agarwal AK, Ahlawat SK, Gupta S, et al. Hypokalaemic paralysis secondary to acute barium carbonate toxicity. *Trop Doct* 1995;25:101–3.
- 5 Clinical aspect of electromyography. In: Amnoff MJ, ed. *Electromyography in clinical practice. Electrodiagnostic aspect of neuromuscular disease*. 2nd ed. New York: Churchill Livingstone, 1987:73–101.

Central pontine myelinolysis causes bilateral loss of deep sensitivity and pseudochoreoathetosis

Central pontine myelinolysis is characterised as symmetric and selective destruction of myelin sheath of the basis pontis. Central pontine myelinolysis often results from rapid increase of serum sodium after hyponatraemia. Patients with central pontine myelinolysis often show symptoms such as conscious disturbances, tetraparesis, and pseudobulbar palsy.^{1–3} We present a case of central pontine myelinolysis due to compensation of hyponatraemia, resulting in acute onset of pseudochoreoathetosis and sensory disturbances.

A 39 year old woman was submitted to a department of internal medicine of another hospital due to a long history of alcoholism, resulting in bad general condition accompanied by severe anaemia, toxic gastritis, and acute pancreatitis. She was alert without any mental disturbances. Laboratory data disclosed metabolic acidosis and hyponatraemia of 126 mmol/l. She received bicarbonate and physiological saline intravenously to compensate for the metabolic disturbances. Serum sodium increased to 136 mmol/l within 3 days. On the third day she suddenly developed severe choreoathetotic movements. Therefore she was transferred to our department of neurology. On the day of submission to our department she remained alert, but she had difficulties in swallowing and speaking. Examination of the cranial nerves showed bilateral ptosis and a dissociated nystagmus on the left side. We also found weakened corneal and pharyngeal reflexes. There was a general reduction of deep tendon reflexes and muscle tone. Muscle strength was normal. Involuntary movements were absent but angle positioning during movements was choreoathetotic. She was unaware of the position of her limbs with closed eyes. We instructed her to watch her limbs and she was then able to reach her nose with the finger. When investigating her sensitivity we found a complete loss of touching, vibration, and position sense in all limbs. Pinprick sensation was unremarkable in the upper limbs, whereas testing of the legs caused a painful burning sensation. Thermal sensation and

T2 weighted MRI (A) sagittal, and (B) axial scan after acute onset of pseudochoreoathetosis: high signal in the central part of the pons.

sensitivity of her face were normal. We excluded tabes dorsalis and vitamin B12 deficiency by laboratory tests. Cranial CT was normal. T2 weighted MRI showed a hyperintense lesion within the pons but no extrapontine myelinolysis (figure). Within 4

weeks the subject's symptoms had nearly disappeared. Only a slight reduction of the vibration sense in all limbs persisted. Control MRI after 4 weeks disclosed an unchanged size of the patient's pontine lesion. At that time nerve conduction velocities and somato-

sensory evoked potentials, which, due to technical reasons, were only performed after the patient's recovery, were normal.

To our knowledge this is the first reported case of central pontine myelinolysis associated with acute onset of movement disorder and isolated affection of proprioceptive sensitivity.¹ The appearance of parkinsonism, dystonia, or choreoathetosis in the course of central pontine myelinolysis are often looked on as symptoms of additional manifestation of extrapontine myelinolysis. The association with manifestation of central pontine myelinolysis remained speculative in some cases of delayed onset of movement disorders after central pontine myelinolysis.¹ By contrast our patient showed an acute onset of pseudo-choreoathetosis after manifestation of central pontine myelinolysis and MRI imaging in our subject disclosed no signs of extrapontine myelinolysis.

Our patient additionally showed an isolated loss of proprioceptive sensation. Disturbances of sensation are described as less severe symptoms of central pontine myelinolysis. Silver *et al*² described an association of sensory ataxia and affection of vibration and position sense, but with reduced pinprick sensation.² This case may imply a further extension of the pontine lesion or a possible extrapontine lesion, not detectable on MRI.² Defebvre *et al* reported two cases of central pontine myelinolysis with isolated affection of deep sensation.³ Isolated affection of the medial lemniscus of the brain stem or thalamic infarction may cause sensory ataxia and disturbances of deep sensitivity resulting in choreoathetotic movements.^{4,5} Therefore, we speculate that our patient's pontine lesion caused sensory ataxia and subsequent pseudo-choreoathetosis, because the movement disturbances appeared without delay after the onset of sensory defects. Moreover, the loss of proprioceptive sensitivity with spared thermal and pain sensation implies an isolated alteration of the medial lemniscus by sparing the spinothalamic tract.⁴ This finding suggests a lesion with a pontine site. We found no extrapyramidal lesion by MRI in our patient. In conclusion we hypothesise that the pontine lesion itself may be a possible cause of our patient's pseudochoreoathetotic movements.

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- 1 Tison FX, Ferrer X, Julien J. Delayed onset movement disorders as a complication of central pontine myelinolysis. *Mov Disord* 1991;6:171-3.
- 2 Silver NC, Barker GJ, MacManus DG, *et al*. Decreased magnetisation transfer ratio due to demyelination: a case of central pontine myelinolysis. *J Neurol Neurosurg Psychiatry* 1996;61:208-9.
- 3 Defebvre L, Rogelet P, Destée A, *et al*. Regressive dystonia and cerebellar ataxia: two unusual symptoms in central pontine myelinolysis. *J Neurol* 1995;242:450-4.
- 4 Roh JK, Lee YS. Bilateral medial medullary infarction manifested as sensory ataxia: a case report and review of the literature. *J Korean Med Sci* 1996;11:193-6.
- 5 Lee MS, Kim DY, Kim JT, *et al*. Abrupt onset of transient pseudochoreoathetosis associated with proprioceptive sensory loss as a result of a thalamic infarction. *Mov Disord* 1998;13:184-6.

Successful treatment of peripheral paraneoplastic neurological syndromes in small cell cancer

Immune mediated paraneoplastic neurological syndromes often become manifest before the underlying malignancy is detected. As a rule, these syndromes do not improve with antineoplastic treatment.¹ We report on a case of a patient with small cell cancer with peripheral neurological syndromes that responded favourably to combination chemotherapy.

At the time of admission the patient, a 66 year old woman, had had a combination of peripheral neurological symptoms for 3 months: (a) muscle weakness and muscle pain of the legs so that she could not walk unattended; (b) a numbness of both legs from the foot to the middle of the thigh; (c) dryness of the eyes and mouth; and (d) severe constipation.

Clinical examination showed a load dependent, proximally accentuated symmetric muscle weakness and hypoaesthesia of the legs. The patient was unable to stand or walk without support. The deep tendon reflexes of the arms were decreased on both sides and leg reflexes could not be elicited. No pathological reflexes were detectable. Analysis of CSF yielded normal values for protein content, cell number, and glucose. Besides a slightly increased erythrocyte sedimentation rate (35 mm in the first hour), standard laboratory values showed no abnormalities. Abdominal auscultation and CT were unrevealing.

Electrophysiological investigation (somatosensory evoked potentials of the tibial and median nerves, EMG, and electroneurography) showed delayed latencies and a reduced amplitude of P40 (tibial SEP), N10, and N13 potentials (median SEP) and polyphasic muscle action potentials. Nerve conduction velocities were on the border of the normal range for the motor peroneal and tibial nerves as well as for the sensory sural nerve. Stimulation of the ulnar nerve with 20 Hz yielded an increment of 60%. Besides a polyneuropathy syndrome, the results of the electrophysiological examinations suggested Lambert-Eaton myasthenic syndrome.

Computed tomography showed a small metastasis of an undetectable primary tumour in a mediastinal para-aortal lymph node, which was immediately resected and histologically identified to be small cell cancer.

As an autoimmune paraneoplastic origin of the neurological symptoms, particularly Lambert-Eaton myasthenic syndrome, was suspected, we measured autoantibodies against presynaptic voltage gated calcium channels by immunoprecipitating ¹²⁵I-conotoxin binding proteins. The antivoltage gated calcium channel titre of 105 pM was positive, although not extremely so. The titre

of antinuclear antibodies was 1:960; most of them were identified as anti-Scl-70. High titre (1:6000) antineuronal antibodies were seen on immunofluorescence of fresh frozen sections of rat cerebellum. Anti-Hu appeared as a prominent band in a western blot of recombinant Hu protein.

As treatment with 3,4-diaminopyridine (10 mg every 4 hours) improved the muscle weakness but had no effect on constipation and the sensory disorder, these symptoms were thought to indicate anti-Hu syndrome. Four cycles of chemotherapy (ACO-I scheme), however, improved all neurological syndromes. Muscle pain and leg hypoaesthesia disappeared, and muscle strength was fully restored so that the patient was able to walk unattended for long distances. The features of Lambert-Eaton myasthenic syndrome were also no longer detectable by EMG. Constipation was alleviated. All types of autoantibodies declined considerably. The antinuclear antibodies titre was reduced to 1:32; immunoprecipitation for antivoltage gated calcium channel antibodies yielded 22.7 pM, which is within the normal range. Antineuronal antibodies were barely detected on sections of rat cerebellum at a serum dilution of 1:32. The anti-Hu signal was also clearly reduced on a western blot. The clinical, physiological, and laboratory findings before and after chemotherapy—that is, six months after admission—are summarised in the table. Combination chemotherapy brought about a considerable and unexpected improvement of two peripheral neurological syndromes (Lambert-Eaton myasthenic syndrome and anti-Hu syndrome with gastrointestinal pseudo-obstruction, muscle pain, and sensory deficits) and a concomitant decrease in autoantibody titres in a patient with small cell cancer.

The results of treatment for paraneoplastic neurological syndromes are still discouraging, despite widespread use of chemotherapy combining antineoplastic and immunosuppressive activity. The reasons for the frequent failures may be irreversible loss of neurons due to autoimmune attack and the differential susceptibility of autoreactive B and T cells inside and outside the blood-brain barrier to the infusion of immunosuppressive drugs. Autoimmune paraneoplastic syndromes involving the CNS are probably caused by intrathecal autoreactive lymphocytes, which may be less accessible to inhibiting drugs than immune cells outside the blood-brain barrier. This hypothesis is supported by the case presented here and by reports of the differential response of central and peripheral syndromes to treatment.^{2,3}

By contrast with the refractory central syndromes, tumour treatment for Lambert-Eaton myasthenic syndrome has been shown to have beneficial effects in many patients. In

at least two cases, a differential response to immunotherapy of peripheral and central syndromes was found in the same patients.^{2,3} In one case,² a patient with paraneoplastic Lambert-Eaton myasthenic syndrome and subacute cerebellar degeneration due to an initially undetected small cell lung cancer, chemotherapy had a beneficial effect on Lambert-Eaton myasthenic syndrome, but not on subacute cerebellar degeneration. In the second case,³ the same combination of peripheral syndromes was caused by a non-Hodgkin's lymphoma. Immunosuppression improved neuromuscular, but not cerebellar symptoms.

Paraneoplastic autoantibodies seem to arise from immunological cross reactions between tumour antigens and normal target proteins. They may take part in the immune response to malignancies, or simply be an epiphenomenon of an immune process triggered by the neoplasm.⁴ The prognosis of patients who mount a humoral antitumour response is usually better than that of patients without response.⁵ The immune process characterised by production of paraneoplastic autoantibodies, however, is a two edged sword. The neurological disorders often associated with some paraneoplastic autoantibodies are so severe that they require immediate treatment, even before a tumour is detected. In such cases, immunosuppressive treatments bear the risk of supporting tumour growth by inhibiting the ongoing immune attack against the neoplasm without interfering with the metabolism of the malignant cells. Therefore, all efforts should be directed at identifying the underlying malignancy. As soon as the presence of a tumour is confirmed, chemotherapy should be initiated to control its growth and to suppress autoantibody production, at least outside the CNS.

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Table 1 Clinical, electrophysiological, and immunological variables before and after chemotherapy in a patient with small cell cancer

	Time of admission	3 Months after chemotherapy
Tumour diameter	3 cm	Not detected
Titre of ANAs	1:960	1:32
IgG titre on rat cerebellum	1:6000	1:32
Anti-Hu	Band in western blot	Declined
Pseudo-obstruction	Present	Absent
Ability to walk unattended	No	Yes
Numbness of legs	Present	Absent
Antibodies against VGCC	105 pM	22.7 pM
Electromyography at 20 Hz	Increment 60%	No increment

ANA=antinuclear antibody; VGCC=voltage gated calcium channel.

1 Voltz RD, Posner JB, Dalmau J, et al. Paraneoplastic encephalomyelitis: an update of the effects of the anti-Hu immune response on the nervous system and tumour. *J Neurol Neurosurg Psychiatry* 1997;63:133-6.

2 Blumenfeld AM, Recht LD, Chad DA. Coexistence of Lambert-Eaton myasthenic syndrome and subacute cerebellar degeneration: differential effects of treatment. *Neurology* 1991;41:1682-5.