respiratory failure. She received metaproterenol, aminophylline, glycopyrrolate, methylprednisolone, erythromycin, and trimethoprim/sulfamethoxazole. Due to increasing difficulty in ventilating the patient, vecuronium therapy was started at 2 mg/h, and titrated between 3 and 5 mg/h over the next 10 days. Midazolam was added for sedation. The patient also received vancomycin, gentamicin, ceftriaxone, metronidazole, and amphotericin for intra-abdominal sepsis.

Twelve days after hospital admission the vecuronium therapy was discontinued and the patient was extubated. She was found to have bilateral muscle weakness: grade 0 to 1/5 proximally, and grade 1 to 2/5 distally. Cranial nerves and sensation were normal. Deep tendon reflexes were 1+ bilaterally. The patient's muscular strength improved over the next 6 weeks.

Results of lumbar puncture were normal. EMG and nerve conduction studies initially refused by the patient were performed 7 weeks after extubation and were compatible with a neuropathic pattern. The patient refused muscle biopsy. Six months later the patient had nearly normal muscle strength.

**DISCUSSION**

The muscle weakness and disuse atrophy experienced by our patients were similar to the findings reported in patients who received pancuronium.11,12 Op de Cool et al11 observed that 12 of 60 patients treated with pancuronium infusions for longer than 6 days (for a total dose of 54 to 1,340 mg) had development of neuromuscular complications, including muscle atrophy, muscle paresis, and cranial nerve paresis. Complete recovery occurred in seven patients over 2 weeks to 5 months, and two patients showed partial recovery after 4 months. EMG in seven of these patients showed denervation and reinnervation abnormalities. Muscle biopsy specimens revealed nonspecific neurogenic denervation and myopathic changes with necrosis. All four nerve biopsy specimens demonstrated axonal degeneration.

These authors, and others,12 concluded that prolonged muscle blockade led to the generalized muscle weakness and atrophy. However, they added that most of the patients were immobile and had received aminoglycosides and corticosteroids that may have contributed to the myopathy.13 Two reports1,2,13 suggested that vecuronium, since it is shorter acting, would be less likely to cause these neuromuscular complications.

Vecuronium is a nondepolarizing neuromuscular blocking agent with fewer cardiovascular effects than pancuronium, and it has primary biliary rather than renal excretion.8 Compared with pancuronium, faster recovery occurs after single dose7 and intermittent bolus8 administration of vecuronium. However, recovery times were markedly prolonged in critically ill patients with renal failure who received continuous vecuronium infusions.8 As recovery times are prolonged, the neuromuscular complications that are seen in patients who have received pancuronium may occur with vecuronium.

Intercostal muscle biopsy specimens of two patients who developed prolonged paralysis and areflexia after prolonged vecuronium infusion revealed changes of denervation and atrophy similar to those seen in the patients who received pancuronium.8 These findings suggest that the diffuse muscle weakness seen in our patients was most likely a result of their receiving prolonged continuous infusions of vecuronium. However, the concomitant use of aminoglycosides and corticosteroids in our patients, as in the other reports,1,2 may indicate a multifactorial etiology to these neuromuscular complications.

In summary, patients who require neuromuscular blockade during mechanical ventilation are at risk of having neuromuscular complications develop. The particular agent used is less important than the duration of immobility, degree of paralysis, and concomitant use of myotenic drugs. To minimize these complications, patients who are receiving neuromuscular blockade need to be closely observed for signs of atrophy or weakness, to enable the clinician to institute aggressive physical therapy and discontinue treatment with the offending drug as soon as possible. It is encouraging to note that the paresis encountered from prolonged neuromuscular blockade is totally reversible in most cases.

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**Phrenic Neuropathy in Arsenic Poisoning**

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A patient presented with acute arsenic neuropathy with asymmetric bilateral phrenic nerve involvement. The clinical and roentgenographic observations of phrenic nerve dysfunction were confirmed by prolonged phrenic nerve conduction time. The patient made a significant recovery with d-penicillamine therapy. (Chest 1991; 100:879-80)

L.G.B = Landry-Guillain-Barré; MRC = Medical Research Council (United Kingdom)

Respiratory dysfunction in neuropathic disorders is well known and may result from paralysis of intercostal muscles or occasionally from diaphragmatic palsy. The diaphragm is involved by lesions of third, fourth, or fifth cervical motor raddicles or of the phrenic nerve. Phrenic nerve involvement is rare and has been reported in association with neuralgic amyotrophy, cervical root evulsions, birth injury, and Landry-Guillain-Barré (LGB) syndrome, or the underlying cause may remain undetermined.1,2 Subclinical involvement of the phrenic nerve has been documented by abnormal phrenic nerve conduction in LGB syndrome, leprosy, hereditary motor sensory neuropathy, and diabetic neuropathy.2,4 Peripheral neuropathy is a well-known complication of acute or long-term arsenic intoxication, which usually presents as sensory motor weakness of short duration.5 Chest infection, without involvement of respiratory muscles or presence of coma, is seen in many patients dying of arsenic neuropathy.4 However, diaphragm palsy due to phrenic neuropathy in such a setting is not reported. A case report of acute arsenic neuropathy with asymmetric bilateral phrenic nerve involvement is presented. The clinical and roentgenographic observations of phrenic nerve dysfunction were confirmed by prolonged phrenic nerve conduction time. The patient made a significant recovery with d-penicillamine therapy. Opium, obtained from clandestine sources, was the source of arsenic poisoning in this case.

**CASE REPORT**

A 35-year-old man, an opium addict, was hospitalized in January 1989, with an illness of six weeks' duration. The presenting symptoms of low-grade irregular fever accompanied by vomiting of ingested food material and watery diarrhea for one week. These symptoms came with ingestion of a new batch of opium. It was later followed by slowly progressive weakness of the lower and then the upper limbs, which was associated with loss of muscle mass and diminished sensations of all the modalities. A few days before admission to the neurology ward, he developed breathlessness. There was no history suggestive of bladder, bowel, or cranial nerve involvement.

On examination, he was anemic, had a pulse rate of 108 beats/min, and blood pressure was 180/100 mm Hg in supine position without postural fall. He had thoracic respiration of the rate of 31/min with paradoxic movements of the abdominal walls during inspiration. Platynychia and Mee's lines over the nails of hand were seen. However, hyperkeratosis of the palms or soles and pigmented changes in the skin were absent. Neurologic examination revealed wasting of limb muscles predominantly in the distal distribution. He was found to have grade 0 power (MRC) in the dorsal flexors of the hands and feet, and grade 4/5 power in the proximal limb girdle muscles. Joint position and vibration sensations were absent, and pin prick and cotton wool touch were impaired over glove and stocking distribution. Deep tendon jerks were absent.

**Figure 1.** Phrenic nerve conduction studies showing increased latency and poor wave formation.

All over, investigations revealed a hemoglobin value of 11.9 g/dl, total leukocyte count, 7,000/cu mm; differential leukocyte count: P68, L30, M1, E1, reticulocytes, 0.2 percent; and erythrocyte sedimentation rate, 45 mm in first hour. Results of blood biochemistry, coagulogram, antinuclear factor, lupus erythematosus cells, and 24-hour urine protein tests were normal. Hepatitis B antigen and Paul Bunnell test results were negative.

Plain x-ray films of the chest and abdomen, intravenous pyelography, and 24-hour urine vanillylmandelic acid excretion test results were within normal limits. Fluoroscopy revealed upward shifts of the diaphragm on either side, right more than the left, which showed poor and paradoxical excursions during inspirations. Cerebrospinal fluid examination was normal. The consumed opium arsenic level was 124 μg/g. Arsenic levels in the urine were raised to 73.5 μg/g and of nails to 7.1 μg/g against a normal of 1.5 to 3 μg/g. Serum and hair arsenic levels were within normal limits. Electromyographic studies of the right abductor pollicis brevis and right deltoid muscles showed neurogenic pattern in the form of dispersed motor unit action potentials of 1 to 1.5 mV amplitude with reduced interference pattern. Nerve conduction studies revealed a right ulnar motor nerve conduction velocity of 15 m/s with terminal motor distal latency of 6.2 ms. Other nerves of the upper and lower limbs, including the right ulnar sensory nerve, could not generate any motor or sensory action potential even on supramaximal stimulus. Phrenic nerve conduction showed delay in conduction time of 22.8 ms on the right and 13.6 ms on the left side (Fig 1), as compared to a control value of 7.47 ± 0.84 (mean ± SD) ms.4

Following diagnosis of arsenic polyneuropathy, the patient received d-penicillamine, 250 mg three times a day. Twenty-four-hour urine arsenic excretion rose to 92.4 μg/g in the first 72 h and became normal by the end of two weeks. Paradoxic diaphragm movements during inspiration disappeared, and by the end of the third week, he was able to stand and walk with little support. The power in the dorsiflexors of the hands and feet improved from grade 0 to 1. After a hospital stay of 27 days, he was discharged receiving antihypertensive drugs, and he was advised to avoid opium. Follow-up three months later showed improvement in hand and foot power by 50 percent. He became almost independent in carrying out his day-to-day activities at home.

**DISCUSSION**

This patient had subacute flaccid symmetric quadripare-
sis, distal more than proximal, with sensory loss which suggested the clinical syndromic diagnosis of motor sensory neuropathy. Dispersion of motor unit potentials along with the increase of amplitude in both the proximal and distal muscles of the upper limbs suggested neurogenic muscle involvement possibly caused by a peripheral nerve demyelinating process. The majority of the upper and lower limb nerves could not generate motor action potentials while the right ulnar motor nerve had decreased nerve conduction velocity of more than 40 percent of the normal control value. There was also delay in the terminal motor latency. These findings of nerve conduction studies favor a demyelinating insult rather than axonal degeneration. Acute massive exposure to arsenic poisoning mostly results in axonopathy; however, subacute arsenic poisoning can cause segmental demyelination or complete blocking of the conduction as seen in this patient. Clinical and electrophysiologic presentation largely depends upon the duration of the insult. In subacute or prolonged cases, the nerve conduction studies may reveal a picture like LGB syndrome. Generalized loss of compound motor action potential or of sensory nerve action potential in the distal muscles of the upper and lower limbs could have suggested an axonal degeneration. However, as this loss is associated with significant dispersion of motor unit potentials, increased amplitude of motor unit potentials, delay in terminal motor latency, and decreased nerve conduction velocities, it suggests a demyelinating process in our patient. Arsenic was found in abnormally high levels in both nails and urine. In many patients, the source of arsenic remains a mystery; however, a new batch of opium detected to have high arsenic content was the source of poisoning in this case. It is the most commonly recognized heavy metal poisoning neuropathy in the Indian subcontinent. It is usually subacute prolonged poisoning which affects the peripheral nervous system along with characteristic skin changes such as hyperkeratosis of palms and soles, hyperpigmentation or raindrop- or teardrop-shaped depigmentation over the skin of the trunk, and Mees's lines over the nails. Arsenic poisoning in the West is mostly accidental or homicidal; however, in the East, arsenic is still used in pesticides, therapeutic powder, and pills by indigenous medical practitioners. In the Indian subcontinent, it is also used in tincture of ginger for potentiating the action of alcohol or opium, which resulted in arsenic poisoning in our case. Arsenic neuropathy usually appears within one to two weeks following ingestion.

In this patient, respiratory discomfort, paradoxical movements of the abdominal wall during inspiration and of the diaphragm in fluoroscopic examination demonstrated diaphragmatic palsy, while prolongation of phrenic nerve conduction time suggested demyelinating insult of the nerve. There were no antecedent events or predisposing factors other than arsenic poisoning which could be identified as the underlying cause of phrenic nerve involvement. The phrenic nerve is predominantly a motor nerve and originates mainly from the fourth cervical segment of the spinal cord. It is augmented by the fibers from the third and fifth cervical motor nerve roots. Bilateral phrenic nerve involvement in association with the motor sensory neuropathy probably reflects a more diffuse process caused by arsenic poisoning. This is further suggested by clinical and roentgenographic improvement which followed d-penicillamine therapy. Diaphragm palsy accompanying brachial neuritis, root avulsion, injury, and leprosy is, most of the time, unilateral. In severe arsenic neuropathy, one must be aware of such a complication for timely respiratory support. Phrenic nerve conduction helps in confirmation or detection of subclinical involvement.

REFERENCES

The Thoracic Vent
Clinical Experience with a New Device for Treating Simple Pneumothorax
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We report recent experience with a new device, the thoracic vent, in the management of simple pneumothorax. There were 16 patients aged 19 to 73 years who suffered pneumothorax due to spontaneous (4), traumatic (3), or iatrogenic (9) causes. Ease of insertion, patient tolerance, and the presence of a unique signal diaphragm all contributed to patient and physician acceptance of the device. Average

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