

## Lambert-Eaton myasthenic syndrome

Udaya Seneviratne, Rajith de Silva

### Summary

**The Lambert-Eaton myasthenic syndrome is a neuromuscular disorder characterised by defective neurotransmitter release at autonomic neurones and presynaptic terminals of the neuromuscular junction. It is caused by an IgG autoantibody formed against especially the P/Q type of voltage-gated calcium channels (VGCC) which is an essential component of the mechanism of neurotransmitter release. Many patients have an associated small cell carcinoma of the lung which appears to provide the antigenic stimulus for antibody production, although there is another group with no underlying malignancy. Both groups show an association with immunological disorders. Assay of VGCC antibody titres and electrophysiological tests help to differentiate Lambert-Eaton myasthenic syndrome from other disorders of the neuromuscular junction. Several drugs and therapeutic interventions capable of producing significant clinical improvement are currently available. Patients should also be investigated for underlying tumours, the specific treatment of which can result in remission or amelioration of symptoms.**

**Keywords:** Lambert-Eaton myasthenic syndrome; voltage-gated calcium channels

Department of Neurology, Institute of Neurological Sciences, Southern General Hospital, Glasgow G51 4TF, UK  
U Seneviratne

Department of Neurology, Essex Centre for Neurological Sciences, Oldchurch Hospital, Romford, Essex RM7 0BE, UK  
R de Silva

Correspondence to Udaya Seneviratne, Institute of Neurology, National Hospital of Sri Lanka, Colombo 10, Sri Lanka

Accepted 16 April 1999

The Lambert-Eaton myasthenic syndrome (LEMS) is an antibody-mediated autoimmune disorder of neuromuscular transmission characterised by muscle weakness, hyporeflexia or areflexia and autonomic dysfunction.

### History

In 1953 Anderson and colleagues reported the case of a 47-year-old man with a bronchial neoplasm, progressive proximal muscle weakness and hyporeflexia who developed prolonged apnoea following administration of succinylcholine. They concluded that there was "strong clinical evidence for believing that the severe muscle weakness was of the myasthenic type".<sup>1</sup> This patient showed the features of what we know today as LEMS.

At a meeting of the American Physiological Society in 1956, Lambert, Eaton and Rooke presented a report on six patients with defective neuromuscular transmission associated with malignant neoplasms. They identified that some of the clinical and electrophysiological features were different from what was expected in myasthenia gravis.<sup>2</sup> Subsequently in 1957, Eaton and Lambert summarised the clinical and electrophysiological characteristics of the myasthenic syndrome.<sup>3</sup>

### Aetiology and epidemiology

LEMS can be broadly divided into two groups depending on whether it is associated with carcinoma or not. However, the electrodiagnostic and clinical characteristics do not differ in those two groups.

Approximately 60% of LEMS patients have associated small cell carcinoma of the lung (SCLC).<sup>4</sup> The incidence of LEMS in patients with SCLC is 3%.<sup>5</sup> Its association with other malignancies has been reported less commonly (box 1).<sup>3-10</sup> O'Neill and colleagues found that in a patient presenting with LEMS the possibility of having an underlying SCLC falls sharply after two years and becomes negligible after 4 to 5 years.<sup>4</sup>

Both groups of LEMS patients have an autoimmune basis suggested by the presence of organ-specific and non-organ-specific antibodies.<sup>4</sup> Various autoimmune diseases and other immunological disorders have been reported in association with LEMS,<sup>4 11-14</sup> which provides further evidence for autoimmunity (box 2).

In LEMS, about 25% of patients have autoimmune diseases and 35-45% are positive for organ-specific antibodies.<sup>4 15</sup> The prevalence of autoantibodies is higher in the group with no underlying carcinoma.<sup>4 15</sup> When both groups are considered together, more than 80% of patients present over the age of 40.<sup>4</sup> Generally, carcinoma-associated LEMS patients tend to present at an older age than LEMS without carcinoma (mean ages 57.9 and 48 years, respectively).<sup>8</sup> If the diagnosis of LEMS is made before the age of 30 it is unlikely to be associated with an underlying tumour.<sup>4 8</sup>

The sex differences in the two groups are less clear. O'Neill *et al*, in their series, found a statistically significant male predominance in the group without associated carcinoma and when both groups were considered together.<sup>4</sup> Male predominance was also seen in the series published by Lennon *et al* in 1982.<sup>15</sup> However, Gutmann and colleagues in 1992 did not find such a sex difference in their study (table 1).<sup>8</sup> This discrepancy in the carcinoma-associated group could be due to changing patterns in smoking, which is a strong risk factor for the development of SCLC.

### Immunogenetics

There is a significant association with HLA-B8 in both groups of LEMS, which appears to be stronger in the group with no associated carcinoma. The frequency

### Malignancies other than SCLC known to be associated with LEMS

- lymphoproliferative disorders
- carcinoma of the breast, colon, stomach, gall bladder, kidney, and bladder
- adenocarcinoma of the lung, pancreas, and prostate
- intrathoracic carcinoid

#### Box 1

### Immunological disorders associated with LEMS

- thyroiditis
- Addison's disease
- vitiligo
- pernicious anaemia
- SLE/DLE
- rheumatoid arthritis
- Sjögren's syndrome
- juvenile-onset diabetes mellitus
- scleroderma
- coeliac disease
- psoriasis

#### Box 2

### Clinical features of LEMS

#### Limbs and trunk

- lower/upper limb weakness: proximal > distal
- exacerbation of weakness by prolonged exercise, hot bath or hot weather
- muscle pain and stiffness
- respiratory muscle weakness: spontaneous or induced by anaesthesia
- depressed or absent reflexes
- post-tetanic potentiation of reflexes

#### Cranial nerves

- symptoms: diplopia, drooping of eye lids, slurred speech, dysphagia, difficulty in chewing, weaker voice, head lolling
- signs: ptosis, neck weakness, jaw weakness, facial weakness, palatal weakness

#### Autonomic features

- dry mouth
- impotence
- constipation
- poor bladder and bowel control
- impaired sweating
- tonic pupils
- orthostatic hypotension/lightheadedness
- impaired oesophageal and intestinal motility

#### Box 3

**Table 1** Sex differences in LEMS with and without cancer

Reference	No of patients	All			With cancer			Without cancer		
		Male	Female	Male %	Male	Female	Male %	Male	Female	Male %
4	50	32	18	64	14	11	56	18	7	72
8	28	12	16	43	6	8	43	6	8	43
15	64	35	29	55	7	11	39	28	18	61

of the immunoglobulin G (IgG) heavy chain marker G1m(2) is also found to be increased in both groups.<sup>16</sup>

### Pathophysiology

The release of neurotransmitters at presynaptic motor nerve terminals of the neuromuscular junction and autonomic neurones depends on the influx of calcium through the voltage-gated calcium channels (VGCC).<sup>17-20</sup> IgG from patients with LEMS has been shown to block the VGCCs.<sup>21</sup> These antibodies result in symptoms by decreasing the release of neurotransmitters. They occur in both groups of LEMS patients.

The VGCCs are classified as L, N, P/Q, R, and T depending on their electrophysiological and pharmacological properties.<sup>22-24</sup> They are found in various tissues, including neuronal cells, neuroendocrine cells and the cardiovascular system. In the nervous system they are present at the neuromuscular junction, autonomic neurones,<sup>19, 20</sup> and the central nervous system, particularly the cerebellum.<sup>25</sup> Different types of VGCCs may co-exist at one synapse.<sup>23, 26</sup>

Acetylcholine release from mammalian motor nerve terminals depends on P/Q type VGCCs.<sup>17, 18</sup> In LEMS, antibodies directed against these VGCCs decrease the release of acetylcholine,<sup>27, 28</sup> resulting in muscle weakness. N, P and Q type VGCCs play a key role in the neurotransmitter release at autonomic neurones.<sup>19, 20</sup> IgG autoantibodies from patients with LEMS have been shown to interfere with neurotransmitter release from postganglionic sympathetic and parasympathetic neurones by down-regulating mainly the P/Q type of VGCCs,<sup>29</sup> which probably explains the mechanism of autonomic dysfunction.

The SCLC tumour cells have been shown to express VGCCs of L, N and P/Q sub-types.<sup>30-32</sup> In SCLC-associated LEMS they appear to provide the antigenic stimulation for antibody production which cross-reacts with the VGCCs in the nervous system. The resulting down-regulation in VGCCs would account for the clinical features.

### Clinical features

Lambert and colleagues in their original series gave a classical description of the clinical features,<sup>2, 3</sup> and these were supplemented in subsequent reports (box 3).<sup>4, 33-35</sup> The cardinal clinical characteristics described by Eaton and Lambert were weakness and fatigability of muscles, temporary increase in strength after voluntary exercise, depressed or absent tendon reflexes, marked sensitivity to curare (as in myasthenia gravis) and relatively poor response to neostigmine.<sup>3</sup> Tendon reflexes show marked potentiation after sustained contraction of the appropriate muscle for 10–15 seconds.<sup>4</sup>

The onset of symptoms is usually gradual and insidious. Occasionally it could be subacute. The commonest presenting symptom is leg weakness. Mild and transient cranial nerve symptoms such as diplopia, drooping of eye lids and dysphagia are reported by around 70% of patients. However, cranial nerve signs are very rare except for ptosis (54%) and weakness of neck flexion (34%).<sup>4</sup> Although patients complain of diplopia, ophthalmoplegia on examination is extremely unusual in LEMS.

Autonomic symptoms are experienced by 80% of patients.<sup>4</sup> Severe autonomic dysfunction may be found on testing even when symptoms are minimal.<sup>36</sup> Both the sympathetic and parasympathetic systems are affected in LEMS.<sup>29, 33</sup>

### Investigations

#### ANTIBODIES TO VGCCS

Over 90% of patients belonging to both groups of LEMS have antibodies against P/Q type VGCCs.<sup>30, 37</sup> This finding appears to be particularly strong in carcinoma-associated LEMS where almost all patients are positive for antibodies against the P/Q type of VGCCs. Antibodies against N type VGCCs are found

**Table 2** Occurrence of anti-VGCC antibodies in LEMS patients (all figures are expressed as percentages)

<i>Antibody type</i>	<i>With lung cancer</i>	<i>With other cancers</i>	<i>Without cancer</i>	<i>All patients</i>	<i>Normal subjects</i>
<i>Lennon et al</i> <sup>30</sup>					
P/Q	100	100	91	95	2
N	73	17	36	49	0
<i>Antibody type</i>	<i>With SCLC</i>	<i>Without cancer</i>	<i>Status uncertain</i>	<i>All patients</i>	<i>Normal subjects</i>
<i>Motomura et al</i> <sup>37</sup>					
P/Q	96	88	93	92	0
N	40	22	47	33	0

in less than 50% of patients when both groups of LEMS are considered together.<sup>30 37</sup> However, when considered separately, these antibodies are found more commonly in LEMS associated with primary lung cancer.<sup>30</sup> Therefore, the detection of N-type antibodies may increase the possibility of finding an underlying primary lung cancer (table 2).<sup>30</sup>

#### ELECTRODIAGNOSIS

Electrophysiological tests are useful for diagnosis as well as for monitoring the course of the illness. Compound muscle action potential (CMAP) after a supramaximal stimulus, postactivation potentiation (increase in the CMAP amplitude immediately after maximal voluntary contraction), repetitive nerve stimulation, and single fibre electromyography often help to differentiate LEMS from myasthenia gravis (table 3).<sup>3 35 38-42</sup> Postactivation exhaustion (decrease in the CMAP amplitude 2–4 minutes after maximal voluntary muscle contraction) is seen in both the LEMS and myasthenia gravis. The results should be interpreted taking the entire picture, including the clinical presentation, into consideration.

The analysis of end-plate potentials and miniature end-plate potentials obtained from *in vitro* microelectrode studies can also help to differentiate LEMS from myasthenia gravis.<sup>38 43</sup>

#### EDROPHONIUM TEST

The edrophonium test may be positive in LEMS but the response is usually weaker than that in myasthenia gravis.<sup>4</sup>

### Treatment options

#### 3,4-DIAMINOPYRIDINE

3,4-Diaminopyridine improves muscle strength and autonomic disturbances in LEMS without serious side-effects.<sup>7 44</sup> It is used for symptomatic relief and is effective in both groups of LEMS. It blocks voltage-gated potassium channels which leads to prolongation of the action potential at motor nerve terminals and the open time of the VGCCs.<sup>45</sup> This process results in increased influx of calcium enhancing quantal neurotransmitter release.

The optimal dose of 3,4-diaminopyridine can vary from 5 mg tid to 25 mg qid. Its beneficial effects are felt about 20 minutes after an oral dose and last for about 4 hours. The maximum response occurs in 3 to 4 days due to cumulative effect. The commonest side-effect is peri-oral paraesthesia. Seizures have been reported in overdosage and rarely at therapeutic dosage.<sup>46</sup>

#### GUANIDINE

Guanidine is an effective drug for symptomatic relief but its use is restricted by serious side-effects, including bone marrow toxicity, nephrotoxicity, hepatotoxicity, dermatitis and atrial fibrillation.<sup>47 48</sup>

#### ANTICHOLINESTERASE DRUGS

Lambert, in his first report, noted the poor response of his patients to neostigmine.<sup>2</sup> Anticholinesterases alone produce mild or no improvement in LEMS. However, they seem to potentiate the effects of 3,4-diaminopyridine.<sup>7</sup> Anticholinesterases can be used in combination with 3,4-diaminopyridine,<sup>7</sup> or low-dose guanidine,<sup>49</sup> to produce symptomatic relief.

#### STEROIDS AND IMMUNOSUPPRESSIVES

The beneficial effect of long-term therapy with prednisolone has been shown in individual case reports.<sup>37 50</sup> A retrospective study has shown that prednisolone combined with azathioprine is more effective than prednisolone alone in LEMS

**Treatment of LEMS**

- 1 For muscle weakness and autonomic symptoms: DAP or DAP + pyridostigmine  
*If DAP is not available:* low dose guanidine + pyridostigmine
- 2 Screen for an underlying malignancy: specific treatment of the malignancy if present
- 3 No response to steps 1 and 2: steroids or steroids and immunosuppressives
- 4 Any patient with severe weakness: plasma exchange or IVIG

**Box 4****Table 3** Electrodiagnostic differences between LEMS and myasthenia gravis

	LEMS	Myasthenia gravis
1 Amplitude of CMAP to a single supramaximal stimulus	Decreased	Normal or near normal
2 Postactivation potentiation	Marked increase in CMAP by more than 100%	May be seen, and when present less marked than in LEMS
3 Repetitive nerve stimulation: At slow rates (2–5Hz)	Decremental pattern	Decremental pattern (>10% decrement in generally considered to be abnormal)
At fast rates (30–50Hz)	Incremental pattern (over 2–20 times)	May show incremental pattern, but usually less marked than in LEMS
4 SFEMG	Increased jitter and intermittent impulse blocking, which improve with higher firing rates	Increased jitter and impulse blocking which get worse with higher firing rates
5 Microelectrode studies: MEPP amplitudes	Normal	Small or undetectable
EPP quantal content	Low	Normal
Distribution of EPP amplitudes	Poisson's distribution	Normal distribution

CMAP : compound muscle action potential; SFEMG : single fibre electromyography; (M)EPP : (miniature) end-plate potential

with no associated carcinoma.<sup>51</sup> Although there are no prospective randomised controlled trials, it is reasonable to consider this option for long-term therapy in patients unresponsive to 3,4-diaminopyridine.

**PLASMA EXCHANGE**

Repeated plasma exchanges have been shown to produce significant symptomatic improvement in LEMS patients,<sup>51–52</sup> reaching a peak at two weeks and subsiding by 6 weeks.<sup>51</sup> It is effective in both groups of LEMS. Plasma exchange is particularly helpful in patients with severe weakness.<sup>51–52</sup>

One of the disadvantages of plasma exchange is lack of selectivity. Protein A immunoabsorption is a technique used to remove IgG from plasma selectively. The success of this method has been reported in a patient resistant to plasma exchange and intravenous immunoglobulin.<sup>53</sup>

**INTRAVENOUS IMMUNOGLOBULIN**

The benefits of intravenous immunoglobulin (IVIG) were first shown in individual case reports.<sup>54–55</sup> In a double-blind, placebo-controlled, cross-over trial involving LEMS patients with no carcinoma, IVIG (1 g/kg body weight/day for 2 days) produced a significant increase in muscle strength peaking at 2 to 4 weeks and effects lasting up to 8 weeks. The clinical response was associated with a significant fall in antibodies to VGCCs.<sup>56</sup> IVIG can be used as an alternative to plasma exchange in patients with severe weakness.

There are no data available on IVIG therapy in LEMS associated with carcinoma; it may well also be effective in this group as the underlying disease mechanism is antibody mediated.

The treatment strategy in individual patients mainly depends on the severity of symptoms, the degree of response to symptomatic treatment, and the presence or absence of an associated malignancy (box 4).

**Management of LEMS associated with SCLC**

These patients can be treated with 3,4-diaminopyridine for symptomatic relief. The specific treatment of the underlying tumour usually results in improvement or remission of symptoms.<sup>57–58</sup> In such patients the only further treatment required may be continuation of 3,4-diaminopyridine. When the specific tumour therapy fails to resolve symptoms, further treatment with prednisolone should be considered.<sup>59</sup> Those who present with severe weakness will benefit from plasma exchange or IVIG.<sup>59</sup>

**Management of LEMS with no associated cancer**

3,4-Diaminopyridine therapy is beneficial in this group and, if successful, no additional treatment is required. Those who have not responded should be treated with prednisolone and/or azathioprine as long-term therapy.<sup>59</sup> Once

remission is achieved, prednisolone could be tapered to the minimum maintenance dose. If the weakness is severe, plasma exchange or IVIG should be considered.

Investigating for an underlying malignancy is an important step in the management of LEMS. In the majority of patients, symptoms of LEMS precede the diagnosis of underlying malignancy, the risk of which becomes low after 4 to 5 years.<sup>4</sup> However, in high-risk patients such as smokers, it is worth undertaking regular screening for SCLC even after this length of time.<sup>59</sup>

- 1 Anderson HJ, Churchill-Davidson HC, Richardson AT. Bronchial neoplasm with myasthenia: prolonged apnoea after administration of succinylcholine. *Lancet* 1953;2:1291-3.
- 2 Lambert EH, Eaton LM, Rooke ED. Defect of neuromuscular conduction associated with malignant neoplasms. *Am J Physiol* 1956;187:612-5.
- 3 Eaton LM, Lambert EH. Electromyography and electrical stimulation of nerves in diseases of the motor unit: observations on a myasthenic syndrome associated with malignant tumours. *JAMA* 1957;163:1117-24.
- 4 O'Neill JH, Murray NM, Newsom-Davis J. The Lambert-Eaton myasthenic syndrome. A review of 50 cases. *Brain* 1988;111:577-96.
- 5 Hawley RJ, Cohen MH, Saini N, Armbrustmacher VW. The carcinomatous neuromyopathy of oat cell lung cancer. *Ann Neurol* 1980;7:65-72.
- 6 Lambert EH. Defects of neuromuscular transmission in syndromes other than myasthenia gravis. *Ann NY Acad Sci* 1955;135:367-84.
- 7 Lundh H, Nilsson O, Rosen I. Treatment of Lambert-Eaton syndrome: 3,4-diaminopyridine and pyridostigmine. *Neurology* 1984;34:1324-30.
- 8 Gutmann L, Philips LH, Gutmann L. Trends in the association of Lambert-Eaton myasthenic syndrome with carcinoma. *Neurology* 1992;42:848-50.
- 9 Argov Z, Shapira Y, Averbuch-Heller L, Wirguin I. Lambert-Eaton myasthenic syndrome (LEMS) in association with lymphoproliferative disorders. *Muscle Nerve* 1995;18:715-9.
- 10 Agarawal SK, Birch BR, Abercrombie GF. Adenocarcinoma of the prostate and Eaton-Lambert syndrome. A previously unreported association. *Scand Urol Nephrol* 1995;29:351-3.
- 11 Gutmann L, Crosby TW, Takamori M, Martin JD. The Eaton-Lambert syndrome and autoimmune disorders. *Am J Med* 1972;53:354-6.
- 12 Deodhar A, Norden J, So Y, Bennett R. The association of systemic lupus erythematosus and Lambert-Eaton myasthenic syndrome. *J Rheumatol* 1996;23:1292-4.
- 13 Ozata M, Odabasi Z, Musabak U, Corakci A, Gundogan MA. A case of Addison's disease associated with the Lambert-Eaton myasthenic syndrome. *J Endocrinol Invest* 1997;20:338-41.
- 14 Tsuchiya N, Sato M, Uesaka Y, et al. Lambert-Eaton myasthenic syndrome associated with Sjogren's syndrome and discoid lupus erythematosus. *Scand J Rheumatol* 1993;22:302-4.
- 15 Lennon VA, Lambert EH, Wittingham S, Fairbanks V. Autoimmunity in the Eaton Lambert myasthenic syndrome. *Muscle Nerve* 1982;5:S21-5.
- 16 Willcox N, Demaine AG, Newsom-Davis J, Welsh KI, Robb SA, Spiro SG. Increased frequency of IgG heavy chain marker G1m(2) and of HLA B8 in Lambert Eaton myasthenic syndrome with and without associated lung carcinoma. *Hum Immunol* 1985;14:29-36.
- 17 Hong SJ, Chang CC. Inhibition of acetylcholine release from mouse motor nerve by a P-type calcium channel blocker omega-agatoxin IVA. *J Physiol (Lond)* 1995;482:283-90.
- 18 Bowersox SS, Miljanich GP, Sugiura Y, et al. Differential blockade of voltage-sensitive calcium channels at the mouse neuromuscular junction by novel omega-cono peptides and Aga IVA. *J Pharmacol Exp Ther* 1995;273:248-56.
- 19 Waterman SA. Multiple types of voltage-gated calcium channel mediate transmitter release from parasympathetic neurons in the mouse bladder. *J Neurosci* 1996;16:4155-61.
- 20 Waterman SA. Role of N-, P- and Q- type voltage-gated calcium channels in transmitter release from sympathetic neurones in the mouse isolated vas deferens. *Br J Pharmacol* 1997;120:393-8.
- 21 Kim YI, Neher E. IgG from patients with Lambert-Eaton syndrome blocks voltage-dependent calcium channels. *Science* 1988;239:405-8.
- 22 Snutch TP, Reiner PB. Ca<sup>2+</sup> channels: diversity of form and function. *Curr Opin Neurobiol* 1992;2:247-53.
- 23 Dunlap K, Luebke JI, Turner TJ. Exocytotic Ca<sup>2+</sup> channels in mammalian central neurons. *Trends Neurosci* 1995;18:89-98.
- 24 Varadi G, Mori Y, Mikala G, Schwartz A. Molecular determinants of Ca<sup>2+</sup> channel function and drug action. *Trends Pharmacol Sci* 1995;16:43-9.
- 25 Volsen SG, Day NC, McCormack AL, et al. The expression of voltage-dependent calcium channel beta subunits in human cerebellum. *Neuroscience* 1997;80:161-74.
- 26 Lemos JR, Nowycky MC. Two types of calcium channels coexist in peptide releasing vertebrate nerve terminals. *Neuron* 1989;2:1419-26.
- 27 Lambert EH, Elmquist D. Quantal components of end-plate potentials in the myasthenic syndrome. *Ann NY Acad Sci* 1971;183:183-99.
- 28 Vincent A, Lang B, Newsom-Davis J. Autoimmunity to the voltage-gated calcium channel underlies the Lambert-Eaton myasthenic syndrome, a paraneoplastic disorder. *Trends Neurosci* 1989;12:496-502.
- 29 Waterman SA, Lang B, Newsom-Davis J. Effect of Lambert-Eaton myasthenic syndrome antibodies on autonomic neurones in the mouse. *Ann Neurol* 1997;42:147-56.
- 30 Lennon VA, Kryzer TJ, Griesmann GE, et al. Calcium-channel antibodies in the Lambert-Eaton syndrome and other paraneoplastic syndromes. *N Engl J Med* 1995;332:1467-74.
- 31 Oguro-Okano M, Griesmann GE, Wieben ED, Slaymaker SJ, Snutch TP, Lennon VA. Molecular diversity of neuronal-type calcium channels identified in small cell lung carcinoma. *Mayo Clin Proc* 1992;67:1150-9.
- 32 Meriney SD, Hulsizer SC, Lennon VA, Grinnell AD. Lambert-Eaton myasthenic syndrome immunoglobulins react with multiple types of calcium channels in small-cell lung carcinoma. *Ann Neurol* 1996;40:739-49.
- 33 Khurana RK, Koski CL, Mayer RF. Autonomic dysfunction in Lambert-Eaton myasthenic syndrome. *J Neurol Sci* 1988;85:77-86.
- 34 Brown JC, Johns RJ. Diagnostic difficulties encountered in the myasthenic syndrome sometimes associated with carcinoma. *J Neurol Neurosurg Psychiatry* 1974;37:1214-24.
- 35 Henriksson KG, Nilsson O, Rosen I, Schiller HH. Clinical, neurophysiological and morphological findings in Eaton Lambert syndrome. *Acta Neurol Scand* 1977;56:117-40.
- 36 Heath JP, Ewing DJ, Cull RE. Abnormalities of autonomic function in the Lambert Eaton myasthenic syndrome. *J Neurol Neurosurg Psychiatry* 1988;51:436-9.
- 37 Motomura M, Lang B, Johnston I, Palace J, Vincent A, Newsom-Davis J. Incidence of serum anti-P/Q-type and anti-N-type calcium channel autoantibodies in the Lambert-Eaton myasthenic syndrome. *J Neurol Sci* 1997;147:35-42.
- 38 Jablecki C. Lambert-Eaton myasthenic syndrome (AAEE Case Report #9). *Muscle Nerve* 1984;7:250-7.
- 39 Maseli RA. Electrodiagnosis of disorders of neuromuscular transmission. *Ann NY Acad Sci* 1998;841:696-711.
- 40 Schwartz MS, Stalberg E. Myasthenic syndrome studied with single fibre electromyography. *Arch Neurol* 1975;32:815-7.
- 41 Elmquist D, Lambert EH. Detailed analysis of neuromuscular transmission in a patient with the myasthenic syndrome sometimes associated with bronchogenic carcinoma. *Mayo Clin Proc* 1968;43:689-713.
- 42 Keeseley JC. Electrodiagnostic approach to defects of neuromuscular transmission (AAEE Minimonograph #33). *Muscle Nerve* 1989;12:613-26.
- 43 Maselli RA, Mass DP, Distad BJ, Richman DP. Anconeus muscle: a human muscle preparation suitable for in-vitro microelectrode studies. *Muscle Nerve* 1991;14:1189-92.
- 44 McEvoy KM, Windebank AJ, Daube JR, Low PA. 3,4-Diaminopyridine in the treatment of Lambert-Eaton myasthenic syndrome. *N Engl J Med* 1989;321:1567-71.
- 45 Molgo J, Lundh H, Thesleff S. Potency of 3,4-diaminopyridine and 4-aminopyridine on mammalian neuromuscular transmission and the effect of pH changes. *Eur J Pharmacol* 1980;61:25-34.
- 46 Sanders DB. 3,4-Diaminopyridine (DAP) in the treatment of Lambert-Eaton myasthenic syndrome (LEMS). *Ann NY Acad Sci* 1998;841:811-6.
- 47 Oh SJ, Kim KW. Guanidine hydrochloride in the Eaton-Lambert syndrome: electrophysiologic improvement. *Neurology* 1973;23:1084-90.
- 48 Cherington M. Guanidine and germine in Eaton-Lambert syndrome. *Neurology* 1976;26:944-6.
- 49 Oh SJ, Kim DS, Head TC, Claussen GC. Low-dose guanidine and pyridostigmine: relatively safe and effective long-term symptomatic therapy in Lambert-Eaton myasthenic syndrome. *Muscle Nerve* 1997;20:1146-52.
- 50 Streib EW, Rothner DA. Eaton-Lambert myasthenic syndrome: long-term treatment of three patients with prednisolone. *Ann Neurol* 1980;8:121-2.
- 51 Newsom-Davis J, Murray NM. Plasma exchange and immunosuppressive drug treatment in the Lambert-Eaton myasthenic syndrome. *Neurology* 1984;34:480-5.
- 52 Dau PC, Denys EH. Plasmapheresis and immunosuppressive drug therapy in the Eaton-Lambert syndrome. *Ann Neurol* 1982;11:570-5.
- 53 Cornelio F, Antozzi C, Confalonieri P, Baggi F, Mantegazza R. Plasma treatment in diseases of the neuromuscular junction. *Ann NY Acad Sci* 1998;841:803-10.
- 54 Bird SJ. Clinical and electrophysiologic improvement in Lambert-Eaton syndrome with intravenous immunoglobulin therapy. *Neurology* 1992;42:1422-3.
- 55 Takano H, Tanaka M, Koike R, Nagai H, Arakawa M, Tsuji S. Effect of intravenous immunoglobulin in Lambert-Eaton myasthenic syndrome with small cell lung cancer: correlation with the titre of anti-voltage-gated calcium channel antibody. *Muscle Nerve* 1994;17:1073-5.
- 56 Bain PG, Motomura M, Newsom-Davis J, et al. Effects of intravenous immunoglobulin on muscle weakness and calcium-channel autoantibodies in the Lambert-Eaton myasthenic syndrome. *Neurology* 1996;47:678-83.
- 57 Jenkyn LR, Brooks PL, Forcier RJ, Maurer LH, Ochoa J. Remission of the Lambert-Eaton syndrome and small cell anaplastic carcinoma of the lung induced by chemotherapy and radiotherapy. *Cancer* 1980;46:1123-7.
- 58 Chalk CH, Murray NM, Newsom-Davis J, O'Neill JH, Spiro SG. Response of the Lambert-Eaton myasthenic syndrome to treatment of associated small-cell lung carcinoma. *Neurology* 1990;40:1552-6.
- 59 Newsom-Davis J. A Treatment algorithm for Lambert-Eaton myasthenic syndrome. *Ann NY Acad Sci* 1998;841:817-22.