Cerebral salt wasting syndrome in meningoencephalitis: a case report

Acute hyponatraemia is a common finding in patients with intracranial pathology. The diagnosis of the syndrome of inappropriate antidiuretic hormone (SIADH) is often made, but it is important to distinguish this from cerebral salt wasting syndrome, which responds to very different management. Cerebral salt wasting is well documented in neurological patients and in patients with space occupying pathology. We present a case of a 26 year old man who developed cerebral salt wasting syndrome during an episode of meningoencephalitis.

Case report

A 26 year old man was admitted through the A&E department to a local district general hospital with four days of episodic confusion. There was no significant past medical or family history. Recreational drug use was denied and a urine screen was negative. A diagnosis of toxic encephalopathy was made. On day 2 he became pyrexial and agitated, and was sedated with haloperidol. Otherwise his examination was unremarkable, and his Glasgow coma scale (GCS) was 15, with no focal neurology. Routine blood tests, chest x-ray, and computed tomography (CT) of the head were normal. CSF examination revealed a lymphocytic picture (130 cells/cm³) with a protein of 1.9 g/l and a glucose of 2.3 mmol/l. On day 8 an EEG revealed anterior delta rhythm activity, consistent with an encephalopathy. Polymerase chain reaction tests for herpex simplex and varicella were negative.

On day 4 he remained pyrexial and confused, and he developed respiratory distress. He became pyrexial and agitated, and was transferred to a tertiary intensive care unit. Repeat routine blood tests, blood cultures, atypical serology, urine, and protected catheter specimens were unremarkable. During day 5 he was rapidly weaned off sedation and extubated. His GCS was 15, with no focal neurology. Over the course of 12 hours his gas exchange deteriorated owing to collapse of his left lung. Following reintubation, bronchoscopy revealed viscid spumt obstructing the left main bronchus. Sedation was again weaned (on day 6) and he developed some complex partial seizures. A repeat CT revealed no intracranial pathology, and repeat lumbar puncture showed a lymphocytosis of 5 cells/cm³. On day 8 an EEG revealed anterior delta rhythm activity, consistent with an encephalopathy. Polymerase chain reaction tests for herpex simplex and varicella were negative.

On day 9 his GCS deteriorated to 8 and he needed increased ventilatory support. An acute hyponatraemia was noted (plasma sodium 132 mmol/l, falling to 123 mmol/l over 12 hours). It was also noted that the central venous pressure fell, urine output increased (6 litres in 24 hours), and he lost 1.5 kg in weight. Biochemistry supported the diagnosis of cerebral salt wasting syndrome, with a high urine sodium loss (148 mmol/l), normal serum osmolality (280 mmol/l), a urine osmolality of 432 mmol/l, and normal urea. In the picture of SIADH one would instead see a relatively normal central venous pressure and a low volume of “inappropriately” concentrated urine (urine sodium > 20 mmol/l and urine osmolality > plasma osmolality). Biochemically, SIADH would be characterised by a lower serum osmolality (< 260 mmol/l) and a low or low normal plasma urea, indicating serum dilution with excess water (table 1).

Intravenous 0.9% saline was begun (initially at a rate of 3.5 ml/kg/h), and a single dose of 100 mg of hydrocortisone was given (table 1). Over the next 16 hours the serum sodium normalised and the high renal sodium loss ceased. During treatment the urine osmolality fell from 432 mmol/kg to 256 mmol/kg, which represents a state of “hyperhydration” as a result of the large volume fluid replacement. He was extubated two days later and went on to make a full recovery.

Discussion

Cerebral salt wasting syndrome was first described by Peters et al., seven years before the identification of SIADH. Despite outward similarities, the pathophysiology, biochemistry, and treatment of these two conditions is very different (table 2). In SIADH there is renal conservation of water and dilutional hyponatraemia. Cerebral salt wasting syndrome is defined as a natriuresis with sodium and water loss and a decrease in intravascular volume. As a result, SIADH is treated by fluid restriction and cerebral salt wasting responds to sodium and water replacement.

Cerebral salt wasting syndrome has been reported in neurological cases and in a case of tuberculous meningitis. However, there are no reports of this condition in other infective neurological processes. Its mechanism has been linked with natriuretic peptides similar to atrial natriuretic factor. Both brain natriuretic peptide and C-type natriuretic peptide have been implicated, and indeed brain natriuretic peptide has been shown to be increased in early subarachnoid haemorrhage.

This case shows the difference between cerebral salt wasting syndrome and SIADH, and the importance of correct diagnosis and correct treatment. In cerebral salt wasting syndrome, saline infusion under central venous pressure guidance will correct the metabolic deficit, and in our case the mineralocorticoid effect of intravenous hydrocortisone helped to reduce the renal sodium loss. The mineralocorticoid fludrocortisone acetate acts directly on the renal tubule to reduce sodium excretion, and Hasan et al. have shown that it significantly reduces the negative sodium balance in similar cases.

M J Brookes, T H Gould
Intensive Care Unit, level 5, Bristol Royal Infirmary, Marlborough Street, Bristol BS2 8HW, UK

Competing interests: none declared

Correspondence to: Dr Matthew Brookes, mbro453398@aol.com

References

A case of familial inverse Marcus Gunn phenomenon

Inverse Marcus Gunn phenomenon is a rare congenital synkinetic movement presenting as eyelid drooping on jaw opening. It has only rarely been reported. Often this phenomenon follows peripheral facial palsy, suggesting abnormal synkinesis of the facial nerve. However, the precise mechanism remains uncertain. Only one electromyographic study has been reported in this condition. In that case, trigemino-oculomotor synkinesis was the supposed mechanism, rather than trigemino-facial synkinesis. We report a patient with familial inverse Marcus Gunn phenomenon and speculate on the neuronal mechanism with the support of electromyographic results.

A 31 year old woman visited our clinic complaining of involuntary wrinking of her left eyelid on jaw opening. The symptom was most prominent when she opened her mouth forcefully, such as when eating or yawning. She stated that the symptom had been noticed from birth, and that her mother and uncle were also affected, but not her two sons. She had no history of previous peripheral facial palsy.

On neurological examination, her extraocular movements were normal and ptosis was not noted. There was no facial paralysis or sensory changes. Masticatory movement or forced mouth opening induced closure of the left eyelid. Her mother showed the same feature on neurological examination. Brain MRI showed no abnormal findings. Facial nerve conduction studies and the blink reflex were normal. Two channel electromyography showed contractions of the left lateral pterygoid muscle and the orbicularis oculi muscle on repetitive masticatory movements (fig 1).

Inverse Marcus Gunn phenomenon, the opposite of the Marcus Gunn phenomenon, is characterised by eyelid closure on jaw opening. Few cases have been reported, most following peripheral facial paralysis. Only one case of congenital inverse Marcus Gunn phenomenon was reported by Lubkin. He observed that on electromyography the levator palpebrae muscle was inhibited or inactivated during jaw opening, without any movement of the orbicularis oculi muscle, and concluded that his patient's symptom was limited to interactions at the level of the third and fifth cranial nerve complexes. Because the Marcus Gunn phenomenon is a pterygo–levator synkinesis between the pterygoid and the levator palpebrae muscles, Lubkin's case may be the true inverse Marcus Gunn phenomenon. However, our patient's electromyographic studies showed that the ipsilateral orbicularis oculi muscle co-contracted with the lateral pterygoid muscle when she opened her mouth. Because these findings were consistently reproducible, we think this phenomenon is caused by synkinesis of the trigeminal and facial nerves in our case.

Most cases of inverse Marcus Gunn phenomenon appear to follow peripheral facial nerve paralysis, with contraction of the orbicularis oculi on jaw opening. However, our patient had no history of peripheral facial paralysis and surprisingly her mother and uncle showed the same phenomenon. We therefore conclude that our patient has a congenital trigemino-facial synkinesis with partial autosomal dominant inheritance. The orbicularis oculi muscle is supplied by the facial nerve connected to maxillary and buccal branches of the trigeminal nerve. As Rana pointed out, ascending proprioceptive impulses from muscle stretch during full mouth opening that are carried in the facial nerve could then trigger contraction of the orbicularis oculi muscle owing to faulty regeneration after a traumatic nerve injury. More recently there has been a tendency to explain these synkinetic movements in terms of plastic change in the central nervous system following deafferentiation. As our patient's symptom is congenital, we suppose that the trigemino–oral synkinesis is a result of an abnormal partial connection between the motor neurones of the trigeminal and facial nerves.

J Y Oh, J E Kim, Y J Kim, K D Park, K G Choi
Department of Neurology, Ewha Womans University, 911-1, Mok-dong, Yangcheon-ku, Seoul 138-710, Korea

Competing interests: none declared

Correspondence to: Dr Jee-Young Oh; seren02@ewha.ac.kr

References

Moderate hypoglycaemia obliterates working memory in humans with and without insulin treated diabetes

Moderate hypoglycaemia is common in people with insulin treated diabetes, and some mental functions deteriorate during this state. Working memory is a crucial cognitive process, necessary for many everyday tasks, but its integrity during hypoglycaemia is not known. We examined the effect of moderate hypoglycaemia on working memory in 32 young adults (16 with type 1 (insulin dependent) diabetes). Mean performance on working memory was reduced already at low levels of chance. During hypoglycaemia, therefore, this important mental ability is almost obliterated though the subjects remain fully conscious. Working memory is the mental capacity simultaneously to store and manipulate information. It supports human capabilities in composing spoken language and in negotiating the environment. Individual differences in working memory correlate very highly with measures of reasoning and general intelligence. Glucose is the brain's principal fuel, and mental function deteriorates when arterial plasma glucose falls below 3.0 mmol/l. Mental functions that are complex and performed under time pressure are particularly affected, the usual finding being a modest reduction in performance. To date, working memory has not been studied during hypoglycaemia. Here we examine the effect of controlled, moderate hypoglycaemia on performance of a challenging working memory task.

Working memory performance was studied in 32 young adults. Sixteen (nine men, seven women) were healthy, non-diabetic subjects aged between 26 and 34 years (mean (SD), 29.6 (1.7) years); a further 16 (nine men, seven women) were otherwise healthy individuals with type 1 diabetes, aged between 20 and 38 years (28.5 (5.4) years). Those with diabetes had a mean HbA1c of 8.3 (0.5%). The mean number of correct items in the national adult reading test was 36.9 (6.1) for the non-diabetic group and 34.6 (5.6) for the diabetic group. Thus both groups comprised people of above average cognitive ability, with an overall mean intelligence quotient of about 113. They were examined under conditions of eu glycaemia (4.5 mmol/l) and hypoglycaemia (2.5 mmol/l). The hyperinsulinaemic glucose clamp technique was used to achieve precise control of arterialised plasma glucose.

Permission to conduct the study was given by Lothian Health medical research ethics committee. Written, informed consent was obtained from all subjects.
The experiment had a repeated measures, counterbalanced design with glycaemic condition as a within subjects factor (repeated measures) between the diabetic and non-diabetic study condition. Subjects also performed the digit symbol test from the Halstead Reitan neuropsychological test battery. Performance on these latter two tasks is known to deteriorate significantly in non-independent measures, NS.

A possible basis for the special vulnerability of working memory to the effects of hypoglycaemia is therefore the interaction of local brain energy demands and the regional density of the cerebral glucose transporters GLUT1 and GLUT3. The degree of hypoglycaemia induced here, which often occurs in people with type 1 (insulin dependent) diabetes, does not affect conscious level. Though many mental tasks show some deterioration in this state, it is remarkable to find a core mental function that the brain is almost totally unable to support.

Acknowledgement
A/9 and VMX/W were funded by Eli Lilly during this research.

Competing interests: none declared.

I J Deary
Department of Psychology, University of Edinburgh,
7 George Square, Edinburgh EH8 9LX, Scotland, UK

A J Sommerfield, V McAulay, B M Frier
Department of Diabetes, Royal Infirmary of Edinburgh,
IJD is the recipient of a Royal Society-Wolfson Research merit award.

Correspondence to: Professor Ian J Deary, i.deary@ed.ac.uk

References
4 Kyllonen PC. Aptitude testing inspired by information processing: a test of the 4-sources model. J Gen Psychol 1993;120:375–405.

Parainfectious opsoclonus-myoclonus syndrome: high dose intravenous immunoglobulins are effective

Opsoclonus-myoclonus syndrome (OMS) is a rare neuro-ophthalmological disorder that affects children more often than adults. Opsoclonus is characterised by involuntary, irregular, but conjugate saccadic eye movements either multidirectional or horizontal (“ocular flutter”) precipitated by change of position. Pathophysiologically, a disordered interaction of “burst” and “omnipause” cells located in the brain stem has been suggested. The associated myoclonus is typically exacerbated by muscle activation and predominantly involves the face, limbs, and trunk. Among various aetiologies of OMS, parapneumonic, paraviral or idiopathic encephalitis are the most common causes and an autoimmune mediated brain stem dysfunction is the suggested underlying pathomechanism.17 Toy favoured childhood OMS occurs predominantly in association with neuroblastoma and ganglioneuroblastoma. Parapneumonic OMS in adults may evolve with lung, breast or uterus cancer, or neuroblastoma.2 Parainfectious and idiopathic forms account for about 50% of cases.3 As OMS is rare there is no standard treatment recommendation. Some cases resolve spontaneously or with symptomatic treatment including clonazepam, valproic acid, piracetam, thiamine, reserpine, chloroethanaole. ACTH seems to be the treatment of choice in children with parapneumonic OMS whereas in adult onset OMS the role of immunotherapy is less well established.4 Here we report a patient with parainfectious OMS whose symptoms were well controlled with repeated administration of high dose intravenous immunoglobulin (1g).

Case report

A few days after recovery from flu-like symptoms a 36 year old computer specialist experienced a subacute evolution of jerking involving his arms and legs that exacerbated while moving his limbs. His gait became increasingly unsteady. He noticed visual instability and reported severe oscilloscopia interfering with reading. He also felt irritable. Neurological examination, performed four weeks after the onset of symptoms showed brief and small amplitude horizontal eye oscillations.
Cerebrospinal fluid (CSF) had 48 white cells/l. Liver function tests was normal as were serum chemistry, including full blood count, electrolytes, and coagulation parameters. Routine laboratory tests revealed normal chest roentgenogram as well as EEG and evoked potentials as well as normal cranial magnetic resonance imaging (MRI) and cerebrovascular angiography. Radiological studies included normal chest roentgenogram as well as normal abdominal and thyroid ultrasonography. Abdominal and thyroid ultrasonography were unremarkable. The patient received prednisolone 500 mg for five consecutive days, followed by oral tapering off. OMS remained unchanged for seven days. Therefore, on hospital day nine a five day course of 30 g/d intravenous Ig was started. Within two days clinical symptoms improved considerably and rapidly. At two month follow up the patient had mild residual opsoclonus and some myoclonic jerks in both upper and lower limbs while standing. OMS remained unchanged for a further six weeks. Combined electro-oculography registrations in each panel, AC recording, time constant 1.6 s) from the splenius capitis muscles on the right and left (SPC r, SPC l). Top and middle, both, the frequency of horizontal conjugate ocular oscillations occasioned by head movements. V ertical, but not horizontal movements. Top, with feet closed while standing (artefact in the electrooculogrammm), irregular myoclonus occurred simultaneously in the right and left tibialis anterior (TAR) muscles without, however, associated myoclonic eye movements (50 Hz artefact in the horizontal eye recording). Bottom, with a normal clinical evolution and a better response to immunotherapy in adults with idiopathic as compared with patients with paraneoplastic OMS. In this series 8 of 10 patients with idiopathic OMS were treated with either intravenous Ig (n=4), corticosteroids (n=2), combined intravenous Ig and corticosteroids (n=1), or azathioprine (n=1). Accelerated recovery was observed in all patients treated with intravenous Ig and in one patient after corticosteroids. In contrast, 9 of 10 patients with paraneoplastic OMS consistently improved after tumour removal whereas immunotherapy with intravenous Ig and corticosteroids alone or in combination as well as plasmapheresis had no effect. Altogether, the available evidence suggests that intravenous Ig is an effective treatment in parainfectious and idiopathic OMS and superior to corticosteroids. Intravenous Ig therefore may prove useful as first line treatment. Moreover, a favourable response to intravenous Ig or other immunotherapies may help to differentiate parainfectious or idiopathic OMS from paraneoplastic forms of the syndrome. The effectiveness of intravenous Ig as an immunomodulatory agent supports the assumption that autoimmune pathomechanisms are involved in the emergence of parainfectious and idiopathic OMS. Treatment with intravenous Ig is safe, very rarely hyperviscosity, and consecutive thromboembolic events may complicate its use.

K Glatz, H-M Meinck, B Wildemann
Department of Neurology, University of Heidelberg, Im Neuenheimer Feld 400, 69120 Heidelberg, Germany

Correspondence to Dr K Glatz; katrinaglatz@med.uni-heidelberg.de

References

www.jnnp.com
Central and peripheral fusiform aneurysms six years after left atrial myxoma resection

Central nervous system embolisation of left atrial myxoma is well documented.1 The most common neurological sequelae is acute cerebral ischaemia secondary to vessel occlusion by tumour.2 Delayed neurological complications are much less common and may result from tumour recurrence with embolisation of progressive vascular stenosis, aneurysm formation with subsequent rupture, or parenchymal metastasis.3 We report the occurrence of multiple myxomatous aneurysms in a patient six years after resection of a left atrial myxoma who was experiencing transient ischaemic attacks in the same distribution as the largest aneurysms. These lesions included bilateral fusiform aneurysms of the superior cerebellar and posterior cerebral arteries.

Case report

A 60 year old woman had a two week history of progressive occipital headache, intermittent visual changes, right facial pain, and incontinence. She had no left upper and lower extremity weakness and mild cerebellar asymmetry. The patient reported a history of left atrial myxoma resection six years before presentation. Atherosclerotic risk factors included high blood pressure, current tobacco use, and raised serum cholesterol. Pertinent drug treatment included fluvasatin and clopidogrel.

Magnetic resonance imaging (MRI) of the brain suggested aneurysms of the superior cerebellar arteries or posterior cerebral arteries. The MRI also revealed areas of previous infarction in multiple vascular distributions including the left superior cerebellar artery and both posterior cerebral arteries. Digital subtraction angiography showed large irregular fusiform aneurysms of the proximal superior cerebellar arteries (fig 1A). Fusiform dilatation of the P1 segment of the right posterior cerebral artery and the P2 segment of the left posterior cerebral artery were also noted. Small peripheral fusiform aneurysms were identified in multiple vascular territories including the right anterior cerebral artery territory and both middle cerebral artery distributions (fig 1B). The angiographic appearance of the aneurysms was not specific and the differential diagnosis included an infectious (bacterial or fungal) or neoplastic etiology (myxoma, choroidal carcinoma), connective tissue disorders (Ehlers–Danlos syndrome, Marfan's syndrome), and neoplastic (for example, neurofibromatosis type 1). There were no branch vessel occlusions. There was no evidence of atherosclerotic disease in the head or neck and no radiographic evidence of myxoma recurrence in the heart.

A right perioral craniotomy was undertaken and showed grossly abnormal superior cerebellar arteries. The right superior cerebellar artery was more involved than the left and had a markedly thickened, whitish, partially calcified wall. No component of the aneurysm was suitable for clipping. The superior cerebellar arteries were reinforced with a cotton wrap before closure. The risk of obtaining a pathological specimen without significant bleeding complications was felt to be too high. Given the history of myxoma resection and lack of clinical or objective evidence for an alternate etiology, the aneurysms were felt to be secondary to remote myxoma embolisation.

Discussion

Cardiac myxomas account for more than 30% of primary cardiac neoplasms, with over 70% occurring in the left atrium.1 Up to 45% of left atrial myxomas embolise systemically, and as many as half involve the cerebral vasculature.2 Neurological symptoms attributable to cardiac myxoma can be categorised as acute or delayed. In the acute setting, tumour embolisation with branch vessel stenosis or occlusion resulting in cerebral ischaemia is the proposed mechanism. It is more common for neurological symptoms related to cardiac myxoma to precede the diagnosis.3 In a Mayo Clinic series of 40 patients with atrial myxoma, 10 (25%) experienced neurological symptoms at the time of diagnosis. Thirty five of these patients were followed for 12 to 235 months; one patient (3%) had a probable delayed neurological complication.

There are several case reports of delayed neurological symptoms related to cerebral myxomatous embolisation, ranging between one and eight years from initial diagnosis and reflecting a unique underlying neuropathology.2 Delayed imaging findings include fusiform and saccular aneurysms, vessel irregularity with stenosis, and intramural metastasis.4,5 Myxomatous aneurysms can rupture, but the risk of this has not been quantified.6 Intracranial myxomatous aneurysms occur with the highest frequency in the peripheral arterial branches of the anterior and middle cerebral artery distribution, although central fusiform aneurysms have been reported.7 Saccular aneurysms are a less common feature of myxomatous emboli.

Thromboembolic events emanating from an aneurysm can result in transient ischaemic attacks, which are radiographically occult. Haemodynamically significant vessel stenosis can cause intermittent ischaemic symptoms. Parenchymal and intraventricular metastases, although uncommon, result in radiographically detectable to the area of brain involved and the mass effect they create.

Two theories on the pathophysiology of myxomatous aneurysms have been widely accepted. The original theory suggested that postembolic vascular damage and subsequent scarring resulted in an alteration of flow dynamics that promoted aneurysm formation.8 In later studies, histopathological evidence showed active invasion of the vascular wall by viable tumour emboli.9-11 The ensuing inflammation and fibrosis weaken the elastic media, resulting in erosion of the arterial wall and subsequent aneurysm formation. This process can be slowly progressive and may help explain why patients with myxomatous aneurysms present several years after resection of the primary tumour. The current case highlights the occurrence of neurological symptoms at a time remote from the initial diagnosis of cardiac myxoma. The development of delayed symptoms is unusual but is well documented, and should be considered in patients with an appropriate history. Although we cannot prove the relation between the symptoms and the aneurysms, we felt it compelling that our patient's transient ischaemic attacks were concordant with the areas of brain supplied by the largest aneurysms. Moreover, the right superior cerebral artery aneurysm was in close proximity to the right trigeminal nerve and could have played a role in her right facial pain. The patient has been stable on maximal medical management.

This case also illustrates the diagnostic value of conventional angiography in detecting vascular neuropathology related to myxomatous embolisation. Although the larger, posterior circulation aneurysms were suspected on MRI, and might have been detected on magnetic resonance or computed tomographic angiography (MRA, CTA), it is less likely that alternate vascular imaging studies would have detected multiple small peripheral aneurysms that are more typical of this disease. Seven of the peripheral aneurysms were detectable only by delayed washout of contrast relative to the arterial phase, a finding that cannot be appreciated on MRA or CTA. Because small peripheral aneurysms are more frequent, the most sensitive vascular imaging study should be used for their detection.
Anti-titin antibodies are not associated with a specific thymoma histology

After the first description of antibodies to titin in patients with thymoma associated myasthenia gravis in 1990, this finding was independently confirmed and the main immunogenic titin epitope in thymomas or else-
determinedly confirmed and the main immunogenic
nia gravis in 1990, this finding was independ-
in patients with thymoma associated myasthe-
after the first description of antibodies to titin
thymoma histology
Anti-titin antibodies are not
be possible to identify the presence of a
carcinoma.
analyzed, 13 from the 1997 study, an
additional nine from the University of Barce-
lona (II), five from the Case Western Univer-
sity Cleveland (HK), and one additional
patient from the University of Erlangen (NS).
No thymoma patients without myasthenia gravis were analyzed. As 10 of the first 14 patients were anti-mgt30 antibodies positive using ELISA but 11 using western blot, we used western blot for defining the antibody status. Thymoma history was classified according to the criteria of Müller-Hermelink into cortical, medullary or mixed thymoma, or a well differentiated thymic carcinoma. A statistical analysis of the correlation was performed using SAS software (Fisher’s exact test).

There was no significant correlation nor a trend for an association between anti-titin antibodies and thymoma histology. Of the six well differentiated thymic carcinomas, three serum samples (50%) were anti-titin positive, as were 11 of the 16 cortical thymomas (69%). All four mixed thymomas were antibody positive.

The presence of anti-titin antibodies may point towards an underlying thymoma. If consistent with radiology, thymectomy is performed also to exclude the presence of an infiltrating thymic carcinoma. As our data now show, titin antibodies are not correlated with thymoma histology and therefore do not add to the presurgical information on the tumour. Why there is no correlation between antibodies and thymoma histology, whether this is attributable to expression of the immunogenic titin epitope in all thymomas or elsewhere independent of the thymoma type, must remain speculation.

Competing interests: none declared.

R Voltz, W Albrich, R Hohlfeld
Institute of Clinical Neuroimmunology, Klinikum Gossau, München, Germany

D Nagel, M Wick
Department of Clinical Chemistry, Klinikum Gossau, München, Germany

T Kirchner
Department of Pathology, University of Erlangen, Germany

N Sommer
Department of Neurology, University of Marburg, Germany

I Illa
Servei Neurologia, Hospital Sant Pau, Universitat Autònoma Barcelona, Spain

H Kaminski
Department of Neurology, Case Western Reserve University, Cleveland, USA

F Schumm
Department of Neurology, University of Erlangen, Germany

Correspondence to: Dr R Voltz; rvoltz@hno.med.uni-muenchen.de

References