Emotion processing in the minimally conscious state

As a newly described condition distinct from coma or the vegetative state, minimally conscious state (MCS) is characterised by a threshold level of consciousness, and diagnostic criteria have recently been proposed. In MCS, cognitively mediated behaviour occurs inconsistently, but is reproducible or sustained enough to be differentiated from reflexive behaviour. It is clinically essential to distinguish this condition from persistent vegetative state (PVS), due to a potentially more favourable outcome. So far, whether patients in MCS can process emotion is unknown.

Cortical processing has been described in PVS using auditory and visual functional paradigms with positron emission tomography. However, to date hardly any functional imaging studies are available in patients in MCS. We used fMRI to assess brain activity induced by an emotional stimulus in a patient in MCS.

A 17 year old man was riding his bicycle when he was hit by a train. The accident resulted in head trauma and immediate coma, progressing to MCS over the course of 4 months, when he was admitted to our institution. This research protocol was approved by the Institutional Ethics Committee. At the time of the fMRI study, 5 months after the accident, the patient localised noxious stimuli, had spontaneous eye opening, detectable sleep/wake cycles, sustained visual fixation, and contingent smiling, thus meeting criteria for MCS. A structural MRI study showed mild cortical atrophy and dilated ventricles. Auditory evoked potentials showed decreased conduction velocities at brainstem level. The patient increased his level of awareness 2.5 months after the functional study was conducted. Auditory evoked potentials after recovery were within normal range, while MRI showed much less ventricle dilatation. Six months after recovering full consciousness, he was able to chat normally and feed himself. Currently we are retesting the patient with the same paradigm.

Non-familiar voice v silence and mother’s voice v non-familiar voice recognition were tested in an fMRI block design with 30 seconds per epoch. The patient listened to his mother reading a story, followed 30 seconds later by an age matched voice reading the same story, for 30 seconds with silence epochs in between. Blood oxygen level dependent images were acquired using a T2 weighted gradient echo planar sequence on a General Electric Signa CVI, 1.5T system with real time image processing of multislice and multi-phase images during patient stimulation and rest periods. The Meds 3.4 Sensor System was used to carry out fMRI post-processing, including motion correction and Gaussian smoothing. An uncorrected significance threshold of P<0.001 was used because amygdala and insula activations was expected, owing to emotional voice processing. Activated clusters were localised following co-registration with an anatomical T1-IR volume.

Subtraction of the phrases read by the age matched voice from silence was the control experiment, showing a significant focus of activation in the transverse and superior temporal gyrus, which spread to the planum temporale; more anterior activation was found in the superior (right) and inferior (left) insula (fig 1A). The subtraction of the mother’s phrases from the age matched voice disclosed a strong activation of the amygdala and insula spreading to the inferior frontal gyrus; there was also weaker activation of the transverse temporal gyrus, temporal operculum, and planum temporale (fig 1B,C). Activation was lower on the right hemisphere in both comparisons, non-familiar voice v silence and familiar voice v non-familiar.

To the best of our knowledge, our results provide for the first time anatomical evidence for the response of an MCS patient to a familiar voice, in which both amygdala and insula appear to play a major role.

The activation pattern of the control experiment agrees with previous studies. Our results showed that the mother’s voice activates the extended amygdala, an emotionally related structure, and a directly connected area such as the insula, perhaps acting jointly as limbic integration cortex. Although residual cerebral activity was unequivocal in our case, representing fragmentary cognitive processing, it should not be assumed that it depicts a fully integrated system required for normal levels of awareness; however, our findings highlight the legal and ethical implications of careless bedside chatter. Whether functional imaging represents a reliable method to evaluate neural processing in MCS patients, in whom cognitive output is extremely difficult to assess, remains to be seen.

References

Figure 1  Brain areas of activation produced by non-familiar voice subtracted from silence in coronal view (control experiment, A). Brain areas of activation produced by mother’s voice subtracted from non-familiar voice in coronal view (B), and in axial view (C)
Neurosyphilis presenting with gummatous oculomotor nerve palsy

Although epidemiological studies suggest that the incidence of primary syphilis is rising, neurosyphilis remains an uncommon manifestation of *Treponema pallidum* infection. In addition, the MRI appearances of this treatable neurological condition are not well known. Many patients with neurosyphilis are asymptomatic, but manifestations include subacute basal meningitis, a meningovascular syndrome of small deep cerebral and cranial nerve infarctions, chronic gummatous inflammation with focal intracranial mass lesions, chronic comportmental dementia of general paresis, and chronic sensory-ataxic myelopathy of tabes dorsalis. We report a case in which a meningeal form of neurosyphilis presented with rapid evolution of a pupil-involving oculomotor nerve palsy to highlight the clinical, CSF, and MRI features and good response to treatment.

Case report

The patient was a 54 year old right handed homosexual man with a history of syphilis of unknown stage, treated with penicillin 25 years previously. He was well until 6 weeks prior to evaluation when he sustained minor head trauma in an automobile accident, followed by intermittent headaches, fatigue, photophobia, and anorexia. Four days before admission he developed worsening and persistent drooping of the right eyelid and double vision. On examination, his mental status was remarkable only for psychomotor slowing. The right pupil was round but enlarged at 6 mm and sluggishly constricted to 5 mm with direct and consensual light stimulation as well as near vision. The left pupil was round and 4 mm and constricted briskly to light. The right eye showed moderate ptosis of the upper lid, and the globe was deviated laterally in primary gaze with markedly impaired adduction and elevation. In the left eye, ptosis was absent and ocular motility was normal. Other cranial nerve, sensory, motor, and reflex functions and gait were normal with the exception of a slight decrease in vibration and position sense in the feet. There were no signs of meningial irritation. Head computed tomodiagram (CT) and CT angiography revealed no blood in the subarachnoid space nor evidence of intracranial aneurysm. MRI of the head (fig 1) showed a spheroid contrast-enhancing lesion at the root of the right oculomotor nerve, which extended towards the cavernous sinus. Incidentally noted were right cerebellar and right frontal developmental venous anomalies. CSF examination revealed normal opening pressure at lumbar puncture, 344 white blood cells (WBCs) (95% lymphocytes), 14 red blood cells (RBCs), protein of 167 mg%, and glucose of 39 mg%, and lactate of 2.6 mmol/l. CSF Venereal Disease Research Laboratory test (VDRL) and serum RPR titres were unchanged. At 6 months, no additional improvement in oculomotor nerve functions was seen but fatigue had subsided. Repeat MRI 7 months after hospital admission showed complete resolution of the oculomotor nerve abnormality.

Discussion

Neurosyphilis is known to cause oculomotor nerve palsies either in the meningovascular phase, due to small vessel vasculitis with resultant nerve infarction, or in granulomatous basal meningitis, due to inflammation of the nerve or its investiture; however, the literature on syphilitic mass lesions around the oculomotor nerve is sparse. Vogl et al reported a case of oculomotor nerve palsy associated with MR findings similar to ours that also resolved with penicillin treatment. Standaert et al described an enhancing penicillin-responsive lesion based in the interpeduncular cistern that compressed the ventral midbrain. The oculomotor nerve lesion in our patient was isointense to adjacent brain on T1 and T2 MR sequences, with brisk enhancement after intravenous injection of gadolinium contrast. We believe the lesion was a manifestation of meningeal syphilis in the form of an oculomotor nerve gumma. A gumma is a focally accentuated, exuberant granulomatous response of the meninges, typically with sparse treponemal organisms. Nonetheless, treatment of the underlying infection quieted the inflammatory process and can, as in our patient, lead to significant reversal of neurological deficit. We add our case to the growing literature on MR correlates of neurosyphilis and encourage a search for neurosyphilis when an unexplained mass lesion is present in the basal subarachnoid space. Neurosyphilis, albeit rare, still deserves inclusion among eminently treatable causes of a rapidly developing oculomotor nerve palsy.

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References


High dose cyclophosphamide for severe refractory myasthenia gravis

Myasthenia gravis (MG) exemplifies autoimmune disease. Most patients require immunomodulating treatment, including steroids, chemotherapmy, or intravenous immunoglobulin (IVIg), in addition to anticholinesterase
treatment. Drachman et al \(^1\) published the beneficial effects of high dose cyclophosphamide in three patients with severe refractory myasthenia. We recount our experience of three myasthenic patients treated in a similar way.

**Materials and methods**

All patients participated in studies approved by the Drexel University College of Medicine and signed informed consent. These three patients with severe (class IVb) refractory MG includes all patients treated. Patients received cyclophosphamide 50 mg/kg (adjusted ideal body weight)\(^\text{d}\) over four consecutive days. Patients received antibiotics, antifungal, and antifungal prophylaxis. Haemorrhagic cystitis prophylaxis included Mesna and forced diuresis. Packed red cells and platelets were transfused to maintain haemoglobin >8.5 g/dL and platelets \(>10 \times 10^9/L\). Patients received filgrastim (G-CSF) (5 \(\mu\) g/kg/day) starting day 10 until their absolute neutrophil count (ANC) reached \(10 \times 10^9/L\) for two consecutive days.

**Results**

Patient 1 was diagnosed with seronegative MG at 30 years of age by a positive tensilon test and a decremental response on repetitive stimulation. Initial treatment included pyridostigmine and thymectomy. It is 26 weeks since her last exacerbation. She presented at 47 years of age with fatigue, weakness, and breathing difficulties. Test results revealed inflammatory demyelinating polyneuropathy from both seronegative MG and chronic inflammatory demyelinating polyneuropathy. She required 27 intubations over 18 months later. Her thymic pathology revealed thymic hyperplasia. Additional treatment included pyridostigmine, intravenous Ig, azathioprine, methylprednisolone, and intravenous Ig, azathioprine, methylprednisolone, and intravenous Ig, azathioprine, methylprednisolone, and intravenous Ig, azathioprine, methylprednisolone, and intravenous Ig, azathioprine, methylprednisolone, and intravenous Ig, azathioprine, methylprednisolone, and intravenous Ig, azathioprine, methylprednisolone, and intravenous Ig, azathioprine, methylprednisolone, and intravenous Ig, azathioprine, methylprednisolone, and intravenous Ig, azathioprine, methylprednisolone, and intravenous Ig, azathioprine, methylprednisolone, and intravenous Ig, azathioprine, methylprednisolone, and intravenous Ig, azathioprine, methylprednisolone, and intravenous Ig, azathioprine, methylprednisolone, and intravenous Ig, azathioprine, methylprednisolone, and intravenous Ig, azathioprine, methylprednisolone, and intravenous Ig, azathioprine, methylprednisolone, and intravenous Ig, azathioprine, 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Acute head drop after cervical hyperflexion injury

Head drop is familiar to neurologists, but not widely appreciated by neurosurgeons. There are multiple causes of this condition in which the patient is unable to hold their head up because of weakness of the neck extensor musculature. It predominantly results from primary muscle pathologies in the neck extensor muscles, with occasional evidence supporting a neurogenic aetiology. 1,2 I describe three patients in whom acute head drop closely followed cervical hyperflexion injury, and suggest that the cause is bilateral traction neurapraxia of one or more cervical dorsal rami.

Patient A was an 84 year old man who enjoyed excellent health prior to falling backwards, striking his occiput on a wall and sustaining forced flexion of the cervical spine. He complained of posterior cervical pain but, when seen in casualty for closure of an occipital laceration, was found to be neurologically intact. Cervical x rays showed only degenerative disease in the mid-lower cervical spine and loss of lordosis. Over 2 weeks the pain in his neck resolved, but he became aware of a difficulty holding his head up as the day progressed and, later, of aching in his neck extensor muscles. He was referred to neurosurgery as a possible case of delayed instability. Cervical x rays demonstrated 5° of forward angulation at C4/5, which did not change with neck flexion, but were otherwise unchanged. He remained neurologically intact but there was progression of the angulation and development of neural injury, posterior segmental fixation at C4/5 with a Harrshill rectangle and sublaminar wiring was advised. Surgery was remarkable only for the absence of significant ligamentous injury or abnormal mobility. Unfortunately, his head ptosis recurred after 2 months. x Rays showed that the sublaminar wires at C5 had “cheese-wired” through the bone and allowed reversion of the 5° of angulation. He remained neurologically intact. After some discussion, he submitted to extended fixation from C3–C7, producing good alignment, albeit with restricted neck movements. However, he had ongoing problems with neck pain because of prominence of the metalwork due to profound atrophy of the paraspinal muscles. Three months later, he again developed head drop because of “cheese-wiring”, and the Harrshill rectangle was removed from the skin, necessitating a third procedure to remove it. At this stage, a muscle biopsy was performed showing end-stage atrophy and fibrosis although no comment could be made as to aetiology. The patient had further investigation or surgery and was managed in a Philadelphia collar in the long term. Despite all the above, the malalignment at C4/5 never progressed, nor did any neurological deficits develop.

Patient B was a fit 72 year old man who sustained a flexion/extension whiplash injury during a road traffic accident (RTA). In casualty, he had minor neck pain but was neurologically intact and had cervical x rays showing only minor degenerative changes and loss of lordosis. He was managed with analgesics and a collar for 6 days after which he returned to casualty complaining of aching in his neck and progressive difficulty in holding up his head throughout the day. Neurological examination showed that cervical x rays showed angulation into 7° of flexion at C5/6, but were otherwise unchanged. He was referred to neurosurgery and at review was strikingly reminiscent of patient A. He had to hold his chin up with a hand to look ahead, had pain in the back of his neck, which developed over the day unless he used his collar, and was neurologically normal, including in the cervical dermatomes. Magnetic resonance imaging (MRI) of his neck revealed normal soft tissue anatomy. A neurological opinion confirmed the normal examination, other than head ptosis. There was no evidence of inflammatory, auto-immune, or neoplastic disease. Clinically, or biochemically, the Tension test was negative, and serum creatine kinase was normal. There were no features of Parkinson’s disease or amyotrophic lateral sclerosis (ALS).

Electroneuromyography (EMG) studies of the neck muscles performed 3 weeks after injury were normal in the ventral muscles, but there were typical features of acute partial denervation in the neck extensors bilaterally, particularly in a band in the mid-to-lower cervical spine with more normal EMGs above and below this. However, electromyography examination of the limbs was abnormal also and consistent with an asymptomatic peripheral neuropathy. The patient declined muscle or nerve biopsy.

In view of patient A’s course and the evidence in patient B of acute denervation that might recover, patient B was managed expectantly. Cervical rehabilitation was used to maintain range of neck movement and encourage use of the neck extensor muscles. He was given a Philadelphia collar, which he wore by day once he became aware of his neck problem. He was given analgesics and a rigid collar. Ten days later he returned to casualty, he had minor neck pain but was neurologically normal, cervical x rays revealed normal soft tissue anatomy. A cervical x ray at C5/6 showed angulation of 7°. The patient was discharged and made a complete recovery. He returned about 1 month later complaining of a new symptom, recurrence of head ptosis at last contact. In view of patient A’s course and the ‘‘whiplash syndrome’’, he was managed expectantly. Cervical rehabilitation was used to maintain range of neck movement and encourage use of the neck extensor muscles. He was given a Philadelphia collar, which he wore by day once he became aware of his neck problem. He was given analgesics and a rigid collar. Ten days later he returned to casualty, he had minor neck pain but was neurologically normal, cervical x rays revealed normal soft tissue anatomy. A cervical x ray at C5/6 showed angulation of 7°. The patient was discharged and made a complete recovery. He returned about 1 month later complaining of a new symptom, recurrence of head ptosis at last contact.

Table 1. The patient’s symptoms in a case of ‘‘typical’’ whiplash syndrome. There is support for this
deviation of neck extensor muscles is unlikely to cause head ptosis. This surgical denervation, however, is unilateral and the denervated muscles are not seen to be grossly abnormal because of secondary changes resulting from the underlying condition. The cat neck extensor muscle biventer cervicis (analogous to human semispinalis capitis) has tendinous insertions defining serially arranged compartments, each receiving segmental innervation from a cervical dorsal ramus. The muscle only generates useful tension if all compartments are co-stimulated; unstimulated compartments act as weak springs in series and dissipate the muscle. There is some evidence for similar architecture in human neck extensors: they receive innervation from several cervical dorsal rami and have tendinous insertions producing several at least partially serial compartments. Denervation of one compartment bilaterally would produce significant weakness and fatigability in such compartmentalised muscles. Additionally, the deeper muscles only traverse one motion segment and are innervated by one posterior primary ramus. Segmental denervation of either type of muscle would lead to angulation at a motion segment, limited by intact joints, ligaments, and disc space.

Whiplash injury can cause neurapraxia of cranial nerve XI, XII, and branches of the cervical plexus,10 and there are other reports of traction neuropathies in the neck.11 In the present cases, the close temporal relationship of the head drop to a forced flexion injury and the EMG findings suggesting acute denervation of neck extensor muscles are consistent with a neurogenic mechanism. Although dystonia of neck flexor muscles can produce head drop, these patients could easily lift their chins and there was no evidence of ventral neck hypertonica on clinical examination. In addition, in patients B and C, there were normal EMG findings in the ventral neck muscles but abnormal findings in the neck extensors.

Neurapraxia of dorsal primary rami would be expected to recover in time. This occurred in patients B and C. Equally, muscle tearing would recover in time, but it is inconceivable that sufficient fibres would have been torn to produce head drop without also producing soft tissue abnormalities on MRI scanning. This is not the case. Only two of the cases were investigated to exclude primary neuro-muscular disorders. These were excluded in patient C. Although patient B had evidence of a pre-existing peripheral neuropathy, this may simply have made him more prone to traction neurapraxia after whiplash and his eventual recovery is consistent with the proposed mechanism.

It is unclear why this syndrome has not been described before. Perhaps most whiplash injuries produce insufficient neurapraxia to provoke head drop unless patient factors adversely affect the transmission of forces to the nerves or their susceptibility to injury. In non-predisposed individuals, sufficiently severe injuries might instead produce fractures/dislocations, whose management masks signs of a concomitant neurapraxia. Less severe injuries might produce head drop, which is either not recognised or recovers quickly and never requires secondary referral. Furthermore, although motor deficits may be rare after whiplash, sensory symptoms may be compatible with the patient’s symptoms in a case of ‘‘typical’’ whiplash syndrome. There is support for this

References


We report a case of acute disseminated encephalomyelitis (ADEM) temporally associated with *Campylobacter* gastroenteritis in a previously fit young man. A PubMed search using the keywords “ADEM,” “demyelination”, and “*campylobacter*” revealed no previous reports of ADEM associated with *Campylobacter* infection in isolation.

A 24 year old man presented to his general practitioner with a history of non-bloody diarrhoea associated with fevers and sweats. His past medical history was unremarkable. He drank 6 units of alcohol per week and had no previous medical history. The general practitioner prescribed loperamide for symptomatic relief. *Campylobacter* species was later isolated from stool samples. By day 5 of his illness, his diarrhoea had settled and he had become constipated. However, he remained febrile and developed nausea and vomiting. His general practitioner prescribed erythromycin but he tolerated only two doses because of nausea.

Fourteen days into the illness he was admitted to hospital complaining of headache, fever, and sweats. Examination revealed a temperature of 38.4°C, pulse of 85 beats/min and normal blood pressure. Rectal examination revealed hard faeces. The cerebrospinal fluid (CSF) analysis revealed a protein of 541 mg/l, glucose of 3.2 mmol/l, and negative oligoclonal banding. No organisms were seen on PCR. The clinical anatomy of the cervical spinal accessory nerve was confirmed by electrophysiological studies. MRI scanning reveals multiple signal abnormalities seen in the subcortical white matter of both hemispheres, which are often quite extensive and enhance with contrast. CSF findings include mononuclear pleocytosis and mild protein elevation. There are few data on evidence based treatment regimens, but treatment is usually instituted with high dose glucocorticoids. Plasmapheresis and intravenous immunoglobulin have also been used.

The pathogenesis of ADEM is not fully understood. However, the evidence suggests that activated T cells, which recognise amino acid sequences shared between microbial epitopes and myelin antigens, attack central nervous system structures alone or in synergy with antibodies. Viral or bacterial superantigens could likewise trigger autoreactive T cells with similar results.

The diagnosis of ADEM is usually made clinically with the aid of MRI scanning, lumbar puncture finding and electrophysiology studies. MRI scanning reveals multiple areas of increased signal on T2 weighted images in the white matter throughout the central nervous system, most commonly the subcortical white matter of both hemispheres, which are often quite extensive and enhance with contrast. CSF findings include mononuclear pleocytosis and mild protein elevation. There are few data on evidence based treatment regimens, but treatment is usually instituted with high dose glucocorticoids. Plasmapheresis and intravenous immunoglobulin have also been used. Huber et al reported a case of combined ADEM and acute motor axonal neuropathy following *Campylobacter jejuni* infection and hepatitis. A immunisation against *Campylobacter* jejuni may be triggered by *Campylobacter*.

Nasralla et al reported a case of postinfectious encephalomyelitis in a young child with *Campylobacter jejuni* enteritis. Cranial MRI scanning showed a combination of predominant grey matter involvement with concomitant foci of lesions in subcortical white matter lesions with no parenchymal enhancement, which the authors felt to be different from the pattern of signal abnormalities seen in patients with ADEM. The MRI abnormalities in our case were in keeping with ADEM although, as with the case reported by Huber et al, the amount of enhancement was minimal, indicating that the majority of the lesions were not acute. The paucity of reported cases of ADEM following *Campylobacter jejuni* infection is surprising given the frequency of *Campylobacter jejuni* infection and Guillain-Barré syndrome and the pathogenesis of the latter. In these cases, *Campylobacter jejuni* induces humeral and cellular immune responses due to molecular mimicry, specific lipopolysaccaride epitopes on the infecting agent and target epitopes on the CNS.

The association of *Campylobacter* infection and Guillain–Barré syndrome is well recognised.

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**Acute disseminated encephalomyelitis temporally associated with *Campylobacter* gastroenteritis**

The association of *Campylobacter* infection and Guillain–Barré syndrome is well recognised.
surface components of the peripheral nerves, resulting in myelin destruction and axonal degeneration. Furthermore, patients with ADEM often have peripheral nervous system involvement and there have been occasional cases of ADEM associated with Guillain-Barré syndrome. Our patient did not have any clinical features suggestive of peripheral nervous system involvement. However, nerve conduction studies were not performed and a degree of sub-clinical neuropathy cannot therefore be excluded.

We describe the first identifiable case of ADEM temporally associated with Campylobacter gastroenteritis alone. Our patient made an excellent recovery associated with therapy with high dose methylprednisolone.

**Acknowledgements**

We are most grateful to Dr D Connolly for reviewing the MRI imaging.

**References**


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**Figure 1** Axial T2 weighted image showing supra- and infra-tentorial high signals in both hemispheres, and coronal T1 weighted images showing peri-trigonal white matter lesions with slight enhancement following intravenous gadolinium DTPA injection in keeping with ADEM.
Acute head drop after cervical hyperflexion injury

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