



## Short communication

## Pathology of bilateral pulvinar degeneration following long duration status epilepticus



Aurelio Hernandez-Lain<sup>a,d</sup>, E. Tessa Hedley-Whyte<sup>a</sup>, Lida P. Hariri<sup>a</sup>, Bradley Molyneaux<sup>b,c</sup>, Keith J. Nagle<sup>e</sup>, Andrew J. Cole<sup>b,c</sup>, Ronan Kilbride<sup>b,c,\*</sup>

<sup>a</sup> Charles S Kubik Laboratory for Neuropathology, Department of Pathology, Boston, MA, USA

<sup>b</sup> The MGH Epilepsy Service, Department of Neurology, Massachusetts General Hospital, Boston, MA, USA

<sup>c</sup> Departments of Pathology and Neurology, Harvard University, Boston, MA, USA

<sup>d</sup> Servicio de Anatomía Patológica (Neuropatología) and Instituto de Investigación i+12, Hospital Universitario 12 de Octubre, Madrid, Spain

<sup>e</sup> Department of Neurology, University of Vermont College of Medicine, Burlington, VT, USA

## ARTICLE INFO

## Article history:

Received 7 March 2013

Received in revised form 16 July 2013

Accepted 17 July 2013

## Keywords:

Status epilepticus

Epilepsy monitoring

MRI

Spinal cord

Medical/systemic disease

## ABSTRACT

**Purpose:** To define the neuropathological findings of pulvinar degeneration seen in long duration status epilepticus.

**Methods:** We review the clinical, radiologic, neurophysiologic, investigational and neuropathological findings on a 27 year old woman who died after 162 days of prolonged refractory status epilepticus.

**Results:** Continuous EEG monitoring confirmed recurrent uncontrolled seizure activity bilaterally and independently, most frequent in the right fronto-temporal region. Initial MRI of the brain was normal. Repeat study until on day 127 of admission showed advanced changes, with bilateral pulvinar T2/FLAIR hyperintensities. The autopsy revealed sharply defined, grey, soft, granular nodules in each medial pulvinar nucleus. Microscopically these consisted of sharply defined paucicellular areas with loss of neurons and myelin and with numerous macrophages in their centers, surrounded by reactive astrocytes with relatively spared of axons. The spinal cord at cervical and thoracic levels showed symmetric spongy vacuolation in the central part of the dorsal columns and lateral corticospinal tracts, with mild myelin loss, relatively preserved axons. The pathological lesions found in this case in the pulvinar are somewhat similar to the pathologic lesions described in Wernicke's encephalopathy. Those found in the spinal cord of our patient resemble characteristic features of B12 related subacute combined degeneration.

**Conclusion:** Characteristic pulvinar degeneration may be found as an acquired phenomenon in prolonged refractory status epilepticus. We hypothesize that the neuropathological findings result from an excessive focal metabolic demand, secondary to neuronal network over activation in the setting of prolonged, frequent bi-temporal seizures.

© 2013 British Epilepsy Association. Published by Elsevier Ltd. All rights reserved.

## 1. Introduction

Acquired neuroimaging changes of the pulvinar nuclei is a known MRI finding in patients with refractory seizures.<sup>2,4</sup> However, only one autopsy study of a patient with new onset

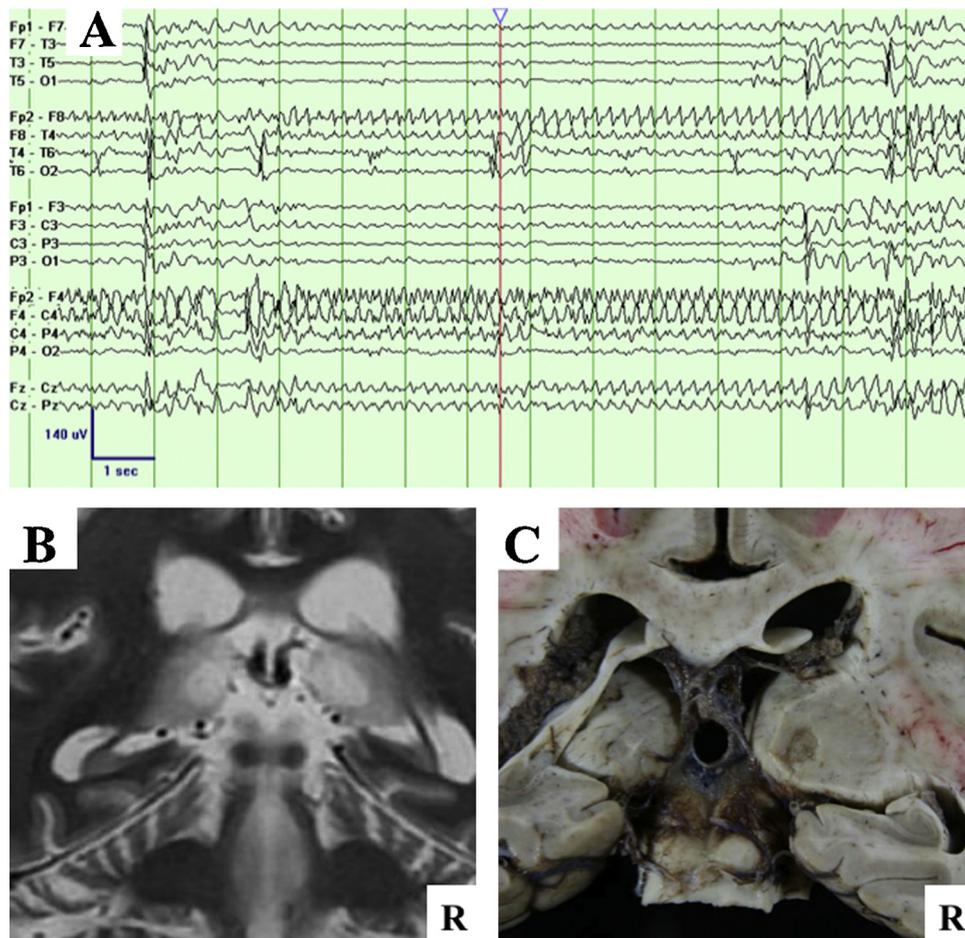
refractory status epilepticus with pulvinar lesions in diffusion MRI has been reported.<sup>1</sup> We report the neuropathological changes in a case with characteristic neuroimaging secondary to prolonged refractory status epilepticus (PRSE) with associated new and novel thalamic and spinal cord pathology.

## 2. Clinical data

27 year old woman with past history of two neonatal febrile seizures, admitted to hospital because of the acute onset of confusion and increasing somnolence, preceded by 5 days of flu-like symptoms and low grade fever. On hospital day 2 she

\* Corresponding author at: Department of Neurology, Massachusetts General Hospital, 55 Fruit Street, WAC 835, Boston, MA 02114, USA/Servicio de Anatomía Patológica (Neuropatología) and Instituto de Investigación i+12, Hospital Universitario 12 de Octubre, Madrid, Spain.

E-mail addresses: [ahernandez.hdoc@salud.madrid.org](mailto:ahernandez.hdoc@salud.madrid.org) (A. Hernandez-Lain), [rkilbride@partners.org](mailto:rkilbride@partners.org) (R. Kilbride).



**Fig. 1.** EEG on day 152 (10 days prior death), showing the right fronto-temporal seizure and independent left temporal sharp waves. (A) Coronal T2 MRI on day 127 at the level of the superior colliculi showing increased signal in both pulvinar nuclei. (B) Coronal sections of the formalin-fixed brain at the corresponding level to A. Note the sharply defined, sunken yellow-gray area in each pulvinar nucleus. The right hippocampus is smaller than the left and the right temporal horn is larger than the left in both B and C. Note the MRI has been reversed so that in both pictures the right hemisphere is on the right (C) (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.).

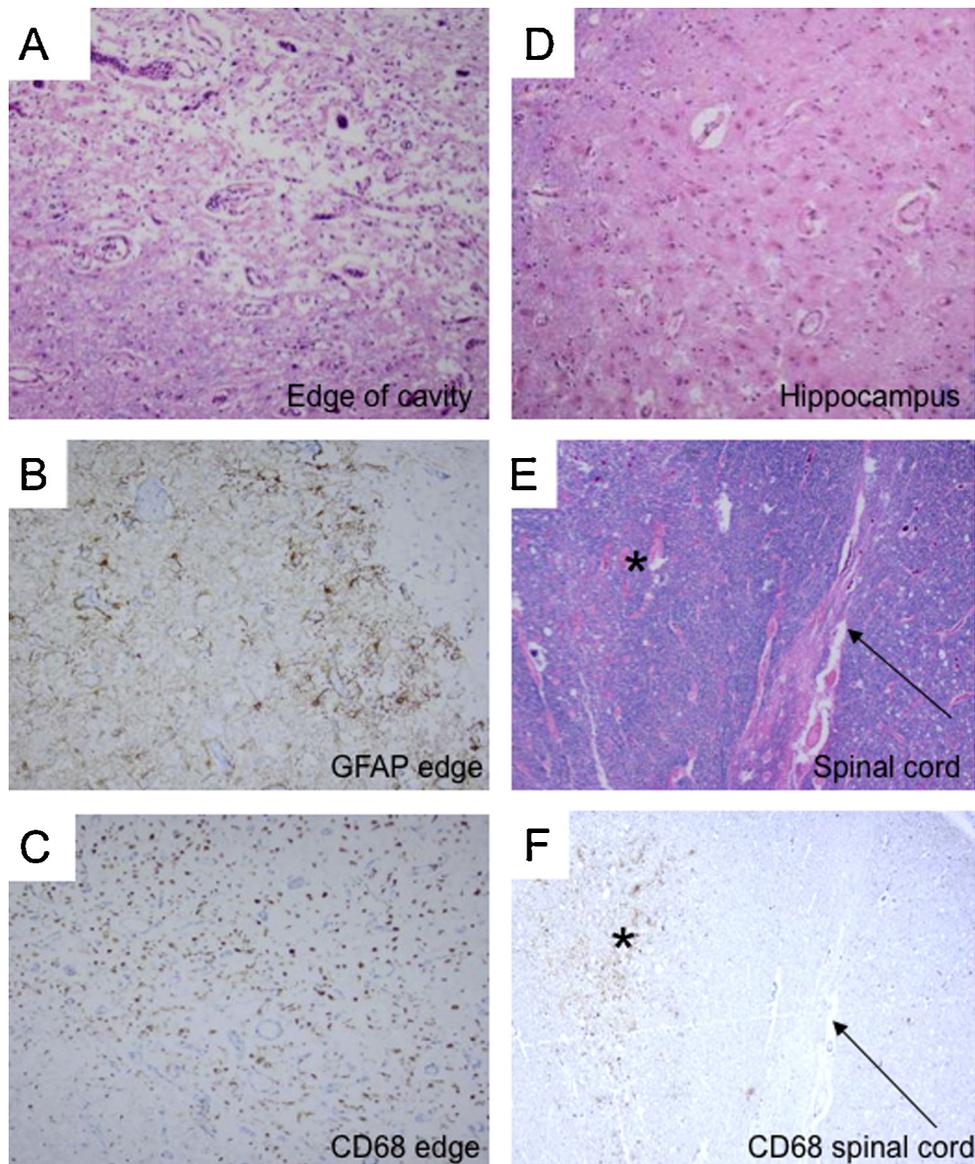
sustained 2 generalized tonic-clonic seizures followed by recurrent medication refractory status epilepticus. Continuous EEG monitoring throughout her illness confirmed recurrent uncontrolled seizure activity bilaterally and independently over both hemispheres but notably most frequent in the right fronto-temporal region (Fig. 1A). These seizures remained refractory to maximal anti-epileptic drug and anesthetic therapies. Despite extensive medical evaluation, including multiple CSF and serum tests and a normal brain biopsy performed on day 14, the cause for the refractory status epilepticus remained cryptogenic. Serum folate and B12 levels on day 84 were normal. Multiple neuroimaging studies (MRI) of the brain were normal until day 127 when an MRI showed new bilateral pulvinar DWI/T2/FLAIR hyperintensities and selective right mesial temporal atrophy (Fig. 1B). In spite of aggressive medical treatment and support, seizures remained uncontrolled, the patient developed renal and cardiac failure, and died on hospital day 162. An autopsy was performed.

### 3. Pathological findings

The brain weighed 1340 g. The right hippocampus was smaller than the left. A sharply defined, gray, soft, granular nodule was

present in each medial pulvinar nucleus, 1.3 cm greatest diameter on the right and 0.7 cm on the left (Fig. 1C).

The nodular lesions in the pulvinar nuclei consisted of sharply defined paucicellular areas with loss of neurons and myelin and with numerous foamy lipid-laden cells in their centers (Fig. 2A), surrounded by reactive astrocytes (Fig. 2B), CD-68 immunostains confirmed that most of the foamy cells were macrophages (Fig. 2C). Neurofilament antibody revealed relatively spared axons within the lesion but with a distorted morphology. The mid thalamus and the periaqueductal gray matter revealed reactive astrocytes and proliferative small blood vessels but no loss of neurons. No abnormalities were found in the mammillary bodies. The right hippocampus showed severe neuronal loss, many reactive astrocytes and capillaries with prominent endothelial cells, particularly in CA1 and to a lesser extent in the subiculum, CA2, CA3 and CA4 consistent with subacute damage (Fig. 2D). The spinal cord at cervical and thoracic levels showed symmetric spongy vacuolation in the central part of the dorsal columns and lateral corticospinal tracts, with mild myelin loss, relatively preserved axons (Fig. 2E). CD-68 immunostains confirmed the presence of macrophages in the spinal tracts with vacuolar changes (Fig. 2F).



**Fig. 2.** Microscopically the center of the pulvinar abnormality is composed of numerous lipid-laden macrophages (A), surrounded by reactive astrocytes (B, GFAP immunostain). Macrophages are highlighted by CD68 immunostain (C). Right hippocampus shows subacute severe neuronal loss and gliosis, most marked in CA1 (D). Dorsal portion of thoracic spinal cord with symmetric spongy vacuolation and macrophages in the center of the dorsal columns (\*) and less marked in the lateral cortico-spinal tract (arrows: posterior horns) resembling the distribution in subacute combined degeneration of the cord (E and F, Luxol fast blue H&E and CD68). A–D 200 $\times$ ; E–F 100 $\times$ .

#### 4. Conclusion

We present a case of PRSE with independent bi-temporal seizures, with pathologically confirmed selective bilateral pulvinar lesions and unilateral acute/subacute hippocampal damage. Although DWI/FLAIR/T2 hyperintensity of the pulvinar nuclei is a known MRI finding in patients with refractory seizures,<sup>2,4</sup> only one autopsy of a patient with new onset refractory status epilepticus with pulvinar lesions in diffusion MRI has been reported.<sup>1</sup> The authors did not describe any macroscopic lesions in the brain. Microscopically they noted only conspicuous neuronophagia within the pulvinar nuclei, suggesting that these findings may be a nonspecific response to sustained and uncontrolled electrical activity in that region. In our patient the sharply demarcated pulvinar lesions corresponding to the neuroimaging were visible to the naked eye. Microscopically these contained numerous macrophages with no remaining neurons, relatively spared axons and a peripheral reactive gliosis.

Both cases may share the same type of brain lesion and the same mechanism, but this could be more severe and at a later stage. The duration of the status was 77 days in Boyd's report, in our case it lasted 162. These lesions were absent in early MRI studies and only found on repeat studies after 125 days of unrelenting status epilepticus, supporting their acquisition over time.

The pathogenesis of these lesions is unclear. Thalamic neuronal loss and DWI MRI changes have been also described in experimental generalized status epilepticus in rats. Ictal activity has been detected in the pulvinar nucleus in patients with TLE after seizure propagation.<sup>3</sup> We hypothesize that the pulvinar lesions are due to an excessive localized metabolic demand in the setting of status epilepticus that could unmask nutritional or vitamin deficiencies. The pathological pulvinar lesions found in this case are somewhat similar to the lesions described in Wernicke's encephalopathy. Although the loss of neurons within the lesions and the preservation of the mammillary bodies are not characteristic of this possibility, the pathological findings in the mid-thalamus and periaqueductal

gray matter, combined with the changes in spinal cord that resemble those seen in subacute combined degeneration, both could support a nutritional deficiency hypothesis.

Another possible etiology considered was ischemia/infarction. It is not possible to rule out completely the possibility that an excess of metabolic demand in the pulvinar, as a result of seizures, has contributed to a relative ischemic damage. Microscopically the pulvinar lesions contained numerous macrophages with no remaining neurons. However, the relative preservation of axons in the center of the lesions, and the pathological changes found in other locations of the thalamus, periaqueductal gray matter and spinal cord would be more in favor of a relative nutritional deficiency as causative etiology, than ischemia.

In summary, we report the neuropathological findings underlying the characteristic imaging findings seen in prolonged refractory status epilepticus. The authors consider the pathogenesis of these bilateral lesions of the pulvinar nuclei, in conjunction with the pathological findings in other locations, to be the result of excessive metabolic demand due to prolonged status epilepticus. This over-burdened metabolic state likely results in relative nutritional/vitamins deficiency as seen here.

### Contributions

The writing work had been shared among Aurelio Hernandez-Lain, E. Tessa Hedley-Whyte, and Ronan Kilbride, but all the others

corrected and approved the manuscript. Patient's clinical evaluation was done by Ronan Kilbride and Andrew Cole; whereas neuropathological exam was conducted by Aurelio Hernandez-Lain, Lida P. Hariri, E. Tessa Hedley-Whyte.

### Funding source

Dr Hernandez-Lain was supported by the Contrato Rio Hortega del Instituto Salud Carlos III.

### Conflicts of interest

The authors declare no conflict of interest.

### References

1. Boyd JG, Taylor S, Rossiter JP, Islam O, Spiller A, Brunet DG. New-onset refractory status epilepticus with restricted DWI and neuronophagia in the pulvinar. *Neurology* 2010;**74**:1003–5.
2. Chatzikonstantinou A, Gass A, Förster A, Hennerici MG, Szabo K. Features of acute DWI abnormalities related to status epilepticus. *Epilepsy Research* 2011;**97**:45–51.
3. Rosenberg DS, Mauguière F, Demarquay G, Ryvlin P, Isnard J, Fischer C, et al. Involvement of medial pulvinar thalamic nucleus in human temporal lobe seizures. *Epilepsia* 2006;**47**:98–107.
4. Szabo K, Poepel A, Pohlmann-Eden B, Hirsch J, Back T, Sedlaczek O, et al. Diffusion-weighted and perfusion MRI demonstrates parenchymal changes in complex partial status epilepticus. *Brain* 2005;**128**:1369–76.