Epileptic Disord 2015; 17 (3): 321-7

Insight into the precuneus: a novel seizure semiology in a child with epilepsy arising from the right posterior precuneus

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Received January 13, 2015; Accepted May 19, 2015

ABSTRACT – To date, there is limited understanding of the role of the precuneus. fMRI studies have suggested its involvement in a wide spectrum of highly integrated tasks, including spatially-guided behaviour, visuo-spatial imagery, and consciousness. We present a patient with intractable parietal lobe epilepsy arising from a lesion localized to the right precuneus. Two seizure types with distinct semiologies were captured on video-EEG monitoring. The first type consisted of an urge described as a "feeling of wanting to move". On video analysis, the patient is seen to turn his head and body to his left. He remains conscious, he is able to answer questions and when asked, he can look to his right. This seizure was associated with an ictal pattern localized to the right parieto-occipital region. The second seizure type consisted of reading-induced visual distortion with macropsia and micropsia. Interictally, intermittent rhythmic slowing and spikes were seen and localized to the parietal midline and the right parieto-occipital regions. Our patient's seizures are positive phenomena of the right precuneus and its related processing network. They represent unique seizure semiologies that offer further insight into the role of the precuneus in spatial awareness, visuo-spatial processing and consciousness.

Key words: precuneus, parieto-occipital, right, video-EEG, semiology, reading

The precise function of the precuneus remains unclear. Its putative role has been in the default mode network, self-awareness, and in a variety of internal processing states. Discerning its function based on loss of function due to lesions, such as stroke, is limited due to its location deep in the interhemispheric fissure and the rare reported cases of circumscribed precuneus lesions in the literature. Moreover, identifying and quantifying the deficit due to loss of processing function is difficult especially in non-eloquent regions. Only functional MRI studies have suggested its involvement in a wide spectrum of highly integrated tasks, including spatially-guided behaviour, visuospatial imagery, and consciousness (Cavanna and Trimble, 2006; Cavanna, 2007). Precuneus seizure semiology can therefore reveal

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doi:10.1684/epd.2015.0759

insights into precuneus function and connectivity. We thus present a patient with posterior precuneus epilepsy and unique seizure semiologies arising from a T2 hyperintense, heterogeneous lesion, localized to the right mesial parietal cortex, anterior to the parieto-occipital sulcus. The seizure semiology, MRI brain findings, interictal and ictal electrographic findings, and neuropsychological evaluation will be reviewed.

Case study

The patient was a 9-year-old, right-handed boy who presented with episodes initially described as dizziness. His medical history, development, and family history were unremarkable and non-contributory. During the episodes, the patient was conscious and able to recall the details of the episodes. He vaguely described the event as episodes where he felt dizzy. As the episodes escalated in duration, the patient was described as not being completely himself, and often he would suffer from severe diffuse migraine headaches afterwards.

Initial imaging with CT showed a hyperdense, non-enhancing right parietal lesion. Subsequent brain MRI showed a lesion localized to the right, mesial, parietal cortex that was isointense with cortex on T1 (see *figure 1a*) and hyperintense and heterogeneous on T2 (see *figure 1b*). The lesion was non-enhancing, and there was no mass effect. A low-grade neoplasm was suspected. On serial imaging over the next four years, the lesion remained stable.

After the diagnosis of epilepsy was made, the patient was initially treated with carbamazepine. The seizure frequency and duration continued to escalate despite dosage titration and addition of other antiepileptic medications. Eventually, the patient developed a second type of event which would be elicited every time the patient would read, even only a few lines of text. It consisted of the words of a text moving off the page and lines of text crossing. The letters of the words could also fluctuate in size. These latter symptoms would result in significant difficulty reading and resulted in learning difficulties for the patient.

Because of the refractory nature of the seizures, the patient underwent prolonged video-EEG monitoring for pre-surgical evaluation. Interictally, there were right parietal and right occipital spikes, moreover, right parietal rhythmic slowing was also present (see *figures 2a and 2b*). The right parietal abnormalities formed the majority of the epileptiform activity.

Two clinical events were recorded. The first event consisted of a "feeling of wanting to move" but there was no clear description of vertigo or other symptoms. When asked, the patient described the "dizziness" as an urge to turn to his left. He denied symptoms of vertigo, sensation of movements, other sensations in his limbs, or any unusual motor activity in his limbs, such as stiffness and shaking. The second event was similar, but longer in duration. On video analysis of the second event, the patient was awake and playing with a toy hammer. He suddenly began to turn his head to his left and then stood and turned his head and body

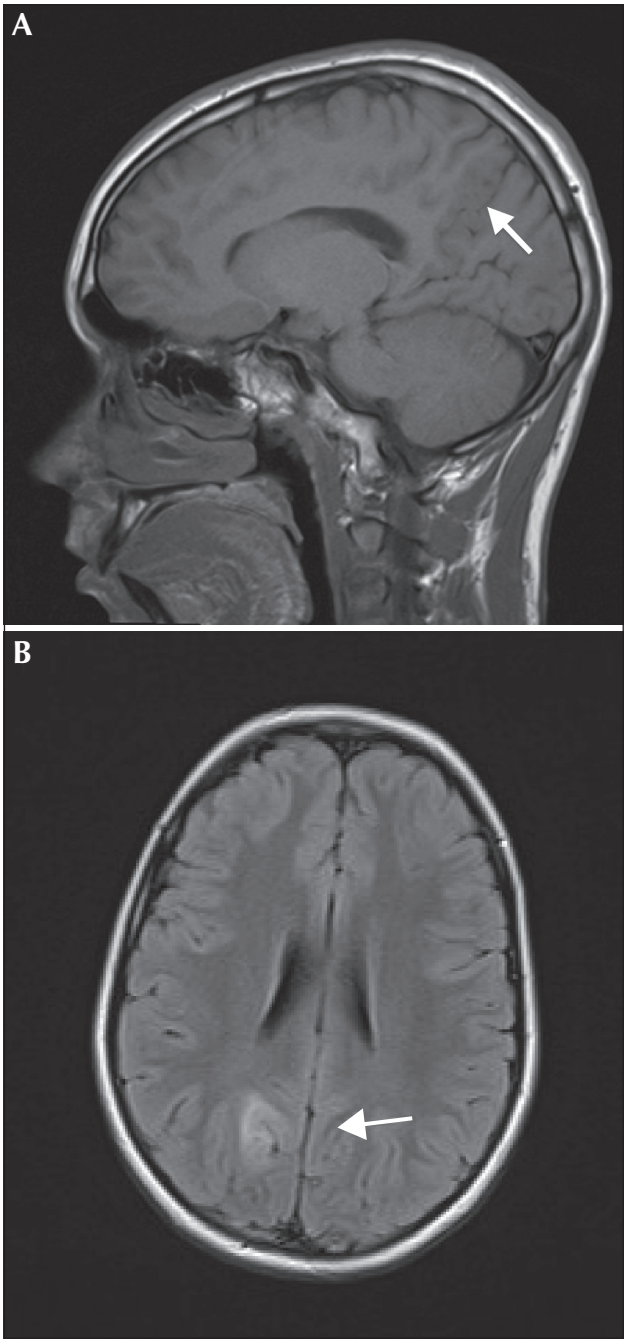

Figure 1. (A) Sagittal T1 MRI showing a lesion that is isointense with cortex and localized anterior to the parieto-occipital sulcus (see arrow). (B) Axial T2 FLAIR MRI showing a hyperintense heterogenous lesion in the mesial, right parietal region (see arrow).

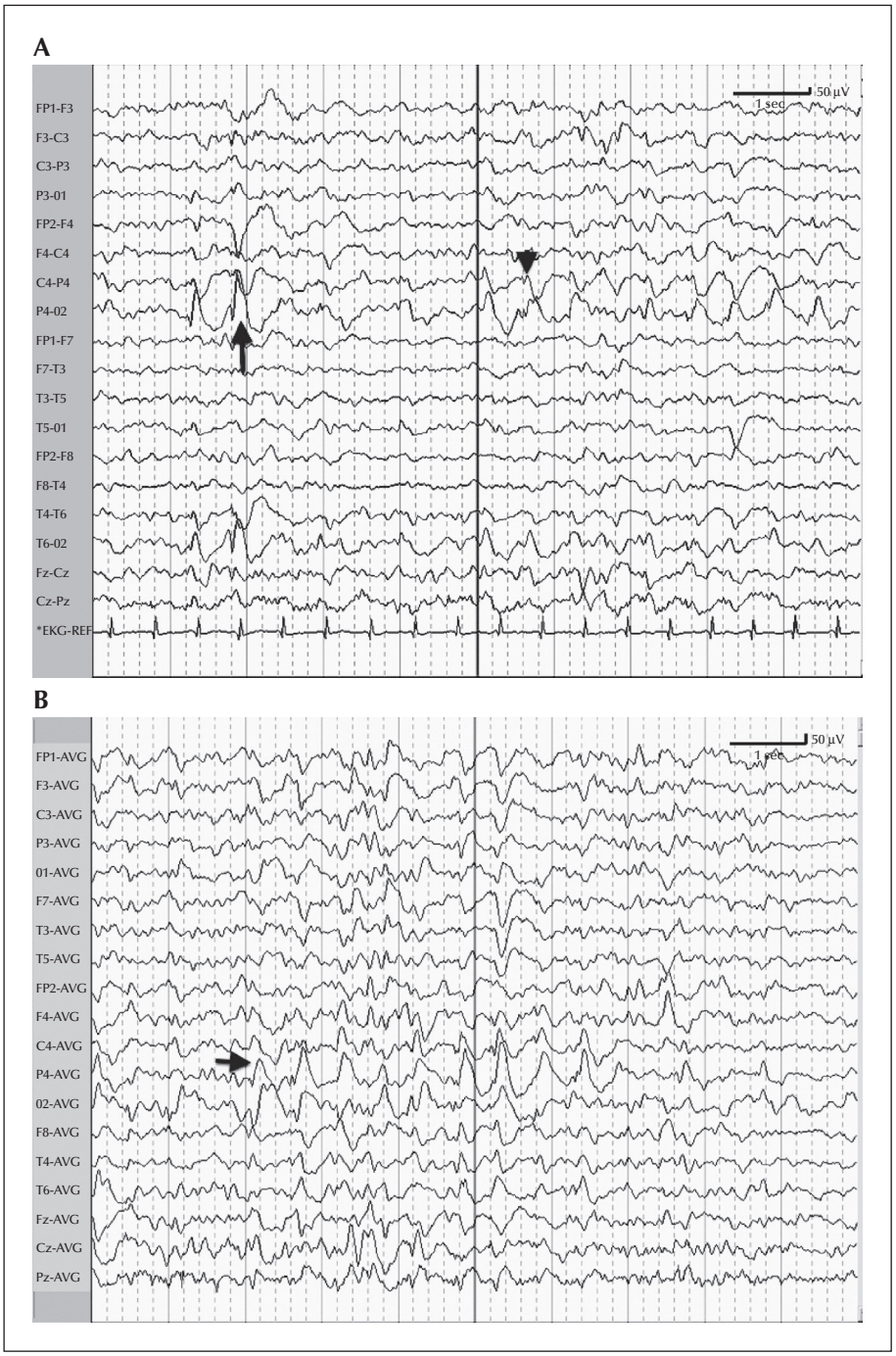

Figure 2. (A) The interictal EEG showing right occipital spikes, right parietal spikes, and right parietal rhythmic slowing on a longitudinal montage. (B) The interictal EEG rhythmic slowing in the right parietal region on an average reference montage.

to his left. He then alerted that he was having a seizure. He remained conscious and when asked, he was able to turn to his right and even focus in primary gaze for a moment, followed by turning his eyes and body to his left again. There was no stiffening or posturing of his limbs, and his speech and comprehension remained normal.

Electrographically, both recorded seizures were similar. The seizure onset consisted of a diffuse 4-5-Hz activity that was maximal in the right parietal region. This activity was followed by right parietal polymorphic, high-amplitude 3-4-Hz activity with admixed right parieto-occipital spikes (maximum at P4/O2) and then right parietal, medium-amplitude

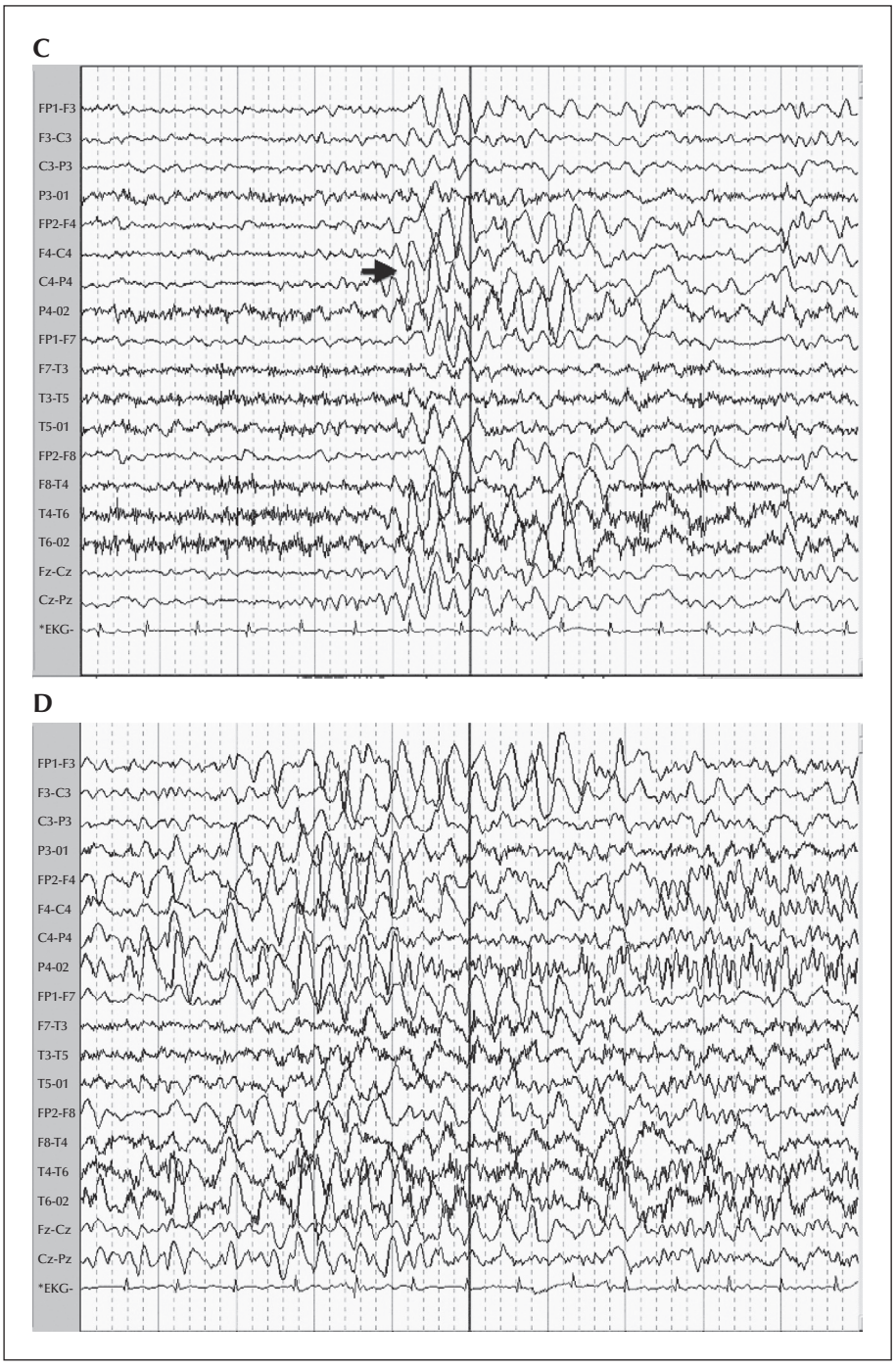

Figure 2. (*Continued*). (C) A longitudinal montage showing the ictal onset characterized by medium-to-high amplitude and rhythmic theta activity that is maximal in the right parietal region. As the seizure progresses, rhythmic spiking can be seen in the right parieto-occipital region, followed by medium-amplitude rhythmic alpha-like activity that remains maximal in the right parietal region. Ictal activity of polymorphic high-amplitude 3-4-Hz activity mixed with parieto-occipital spikes (D) and right parietal medium-amplitude alpha activity (E) is also seen.

alpha activity (see *figure 2c, 2d, and 2*e). The clinical onset of the seizure, as seen on the video when the patient stops his activity and looks up, occurred seven seconds after the electrographic onset. The patient's symptoms associated with reading were elicited on video-EEG, however, these symptoms were not associated with any significant EEG changes.

Figure 2. (*Continued*).

Neuropsychological assessment showed normal to very superior functioning across almost all neuropsychological domains (WISC-IV verbal comprehension score above 99% and perceptual reasoning index above 97%) and mild signs of finger dysgnosia and slower fine motor coordination specific to the left hand.

Because the neurosurgeon had a concern, that the resection of the lesion would likely result in a visual field deficit and other possible visual changes such as visual inattention, the family declined surgery in favour of further medical therapy. Eventually, the majority of his seizures became controlled with five antiepileptic medications. However, the reading-induced visual distortions persisted, albeit at a much lower intensity, such that the patient had developed strategies to read and succeed academically.

Discussion

Lesions restricted to the precuneus are rare and the symptoms arising from this richly connected multimodal associative area (Cavanna, 2007) can be vague and at best poorly described. Three distinct patterns of functional connectivity have been demonstrated within the precuneus: the anterior precuneus exhibits functional connectivity with sensorimotor regions, the central precuneus appears to be a cognitive/associative region, and the posterior precuneus displays functional connectivity with adjacent visual cortical regions (Margulies *et al*., 2009; Cauda *et al*., 2010).

To date, the described seizures from parietal lesions often are attributed to distant symptomatogenic zones. Bilateral asymmetric tonic seizures, for example, have been associated with anterior precuneal lesions and are thought to be a result of propagation to the ipsilateral supplementary motor area and premotor cortex (Umeoka *et al*., 2007).

Unusual seizure semiologies have also been ascribed to the precuneus. Startle-induced seizures had been associated with an epileptogenic zone in the precuneus (Saeki *et al*., 2009) and attributed to the precuneus' suspected role in the startle-induced network (Fernandez *et al*., 2011). Wiest reported a patient with "epileptic linear self-motion" perception caused by ependymoma in the right paramedian precuneus. The main symptom consisted of a vague feeling of swaying and unsteadiness. They postulated that the interictal symptoms were likely the result of the precuneus' role in processing of otolithic and vestibular information (Wiest *et al*., 2004).

In contrast to the semiologies described in the literature, in our patient, it was very clear that the seizures consisted of a "feeling of wanting to move" and the

patient was explicit in denying any symptoms suggestive of perception of a movement, vertigo, syncope, a sense of imbalance, or any other sensations in his body. Although our patient's seizures did not alter his responsiveness, his ictal consciousness may have been somewhat altered by his specific urges to move, and his visual distortions. The preserved alertness is in keeping with an emerging evidence that precuneus belongs to the neural network subserving awareness and conscious self-percept (Cavanna, 2007).

Although our patient's seizure consisted of turning of his head and body to his left, his seizure was not versive in nature as the movement was non-forced (Chee, 2000), but voluntary, as suggested when he was able to stop turning to the left, and turned his body to his right on command. There are a few possible explanations for our patient's urge to move. It may be a reflexion of the precuneus' role in motor imagery (Stephan *et al*., 1995) and its involvement in directing spatial information that is to be processed (Thompson *et al*., 2009; Cauda *et al*, 2010). The precuneus is hypothesized to have a role in generating spatial information for imagined or planned body movement (Ogiso *et al*., 2000). Another explanation for an urge to move is a role of the posterior precuneus in visual attention and visually-guided saccades. Not surprisingly, a haemorrhagic lesion in the right precuneus was reported to lead to an inability to navigate in a real-world situation (Suzuki *et al*., 1998). We believe our patient's reading-induced visual distortions to be a reflexogenic seizure given its reduction with antiepileptic medications. These elicited symptoms are in keeping with the observation that complex somatosensory stimulation can trigger parietal lobe seizures (Williamson *et al*., 1992). Based on the literature, our patient's reflexogenic seizure is likely a consequence of the precuneus' role in multiple visual sensory integration systems, such as oculomotor output processing (Cauda *et al*., 2010), smooth pursuit eye movements, and visuospatial imagery (Cavanna and Trimble, 2006).

The defined localization of a right posterior precuneal lesion and the corresponding right parietal interictal and ictal activity do suggest that our patient's seizures are positive phenomena of the right precuneus and its related processing network. His reading-induced visual distortions and the clear voluntary component of our patient's urge to move to his left during his typical seizure represent unique seizure semiology that offers further insight onto the behavioural correlates of this under-investigated cortical region, specifically in its role in consciousness, spatial awareness and visuospatial processing. □

Supplementary data.
Summary didactic slides are available on the www.epilepticdisorders.com website.

Disclosures.
None of the authors have any conflict of interest to disclose.

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TEST YOURSELF

(1) What is the anatomical location of the precuneus?

(2) What are the presumed functions of the precuneus?

(3) What are the functional subdivisions of the precuneus?

Note: Reading the manuscript provides an answer to all questions. Correct answers may be accessed on the website, www.epilepticdisorders.com, under the section "The EpiCentre".