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Letter to the Editor

## Diagnosing Kernohan-Woltman notch phenomenon by somatosensory evoked potentials in intensive care unit

Kernohan-Woltman notch phenomenon can occur after hemispheric brain lesions with severe midline herniation. This is clinically defined by the existence of false-localizing signs (such as an ipsilateral hemiparesis) due to a contralateral mesencephalon compression by the tentorial edge, without contralateral hemiparesis by temporal lobe herniation (Codd et al., 2013). Repetitive somatosensory evoked potential (SEP) recordings have been used to help assessing secondary injury related to severe herniation on the intensive care unit (ICU), even if they were not brought to evidence by intracranial pressure (ICP) monitoring (Stocchetti and Maas, 2014). It has been proposed previously that continuous SEP recordings in ICU may either predict an increase of ICP or assess the consequence of ICP on brain function (Amantini et al., 2009).

We hypothesised that the N20 response of SEPs could also detect an infra-clinical equivalent of the Kernohan-Woltman notch phenomenon during coma if motor responses are not usable with a sufficient level of confidence. We used gold standard evoked potentials (Micromed®, Italy) for Patient 1 as previously described (Logi et al., 2003). For Patient 2, we used a bedside SEP-monitoring device of the N20 somatosensory cortical response (Dolosys®, Germany), with 500 stimulations (Baars and von Klitzing, 2017). For both patients, Brainstem Auditory Evoked Potentials (BAEPs) were assessed using a standard technique (Micromed®, Italy) as soon as possible after SEPs to have a complementary assessment of the brainstem function (Logi et al., 2003).

Patient 1 presented a spontaneous left parietal intracerebral hematoma with increased Intra-Cranial Pressure (ICP). This hematoma had been evacuated before his admission in ICU. The CT-scan at Day 1 showed a falcine herniation (Fig. 1A). At Day 4, we observed an increased ICP revealing a secondary oedematous phase, which was medically treated. The CT scan indicated a right-mesencephalon compression respecting the left perimesencephalon cisterna (Fig. 1A). SEPs showed a paradoxical right-hemispheric SEPs abolition while BAEPs were normal at the same time (Fig. 1B). N20 remained abolished at Day 16 (not shown) while the patient remained unconscious but he finally reached a Minimally Conscious State before leaving ICU. The MRI performed at Day 25 confirmed the anatomical feature of the Kernohan-Woltman notch phenomenon assessed by an ischemic lesion and a blood-brain barrier alteration at the upper mesencephalon level on the right side (Fig. 1C).

Patient 2 had a post-traumatic right acute subdural hematoma. The CT-scan on Day 1 showed a falcine herniation and left-mesencephalon compression respecting right-perimesencephalon cisterna (Fig. 2A). The amplitude of the contralateral N20 was reduced and then abolished 2h30 later (Fig. 2B). While the left N20 response disappeared, the occurrence of a left mydriasis led to evacuate the hematoma two hours later despite a low ICP (below 20 mmHg). Abolition of the SEP remained the day after surgery (despite normal BAEPs), then recovered at Day 8 after trauma while the patient completely awoke. An MRI was performed at Day 13, which confirmed the sequela of a Kernohan-Woltman notch phenomenon despite the intervention and the favourable clinical outcome.

SEPs at bedside in ICU might be useful to reveal compressive injury at the upper mesencephalon level after supratentorial lesions. The example of Patient 1 allows us to introduce the concept of an infra-clinical equivalent of the Kernohan-Woltman notch phenomenon in case of increased ICP as a possible mechanism for concomitant alteration of the cerebral perfusion pressure and SEPs (Amantini et al., 2009) or BEAPs (Garcia-Larrea et al., 1992). In some other cases (illustrated by Patient 2), a brain functional alteration can be missed by a standard monitoring by ICP, which might not be sensitive enough to detect the consequences of herniation of strategic anatomical areas (Stocchetti and Maas, 2014). In the same vein, BAEPs can fail to bring them to evidence if the lower mesencephalon is respected (Fischer et al., 1995) and if the lesion takes place at the upper mesencephalon level or at the mesencephalon-diencephalon junction.

Altogether, the paradoxical signs of Kernohan-Woltman notch phenomenon can be recorded by a neurophysiological monitoring. Interestingly, SEPs seems to be better suited than BAEPs to demonstrate the evolution of this paradoxical functional deterioration as the consequences of herniation could concern mostly the upper part of the mesencephalon. A continuous and low invasive monitoring of the mesencephalon-diencephalon integrity might be of great interest for ICU management in case of sedated patients for whom ICP remains low despite severe herniation.

## Disclosures

Jan H. Baars is an anesthesiologist and CEO of Dolosys GmbH, a spin-off from the Department of Anesthesiology of the Charité – Universitätsmedizin Berlin. Dolosys received funding from Federal Ministry for Economic Affairs and Energy and the Investment Bank of Berlin.

*Abbreviations*: ICP, Intra-Cranial Pressure; BAEPs, Brainstem Auditory Evoked Potentials; SEPs, Somatosensory Evoked Potentials.

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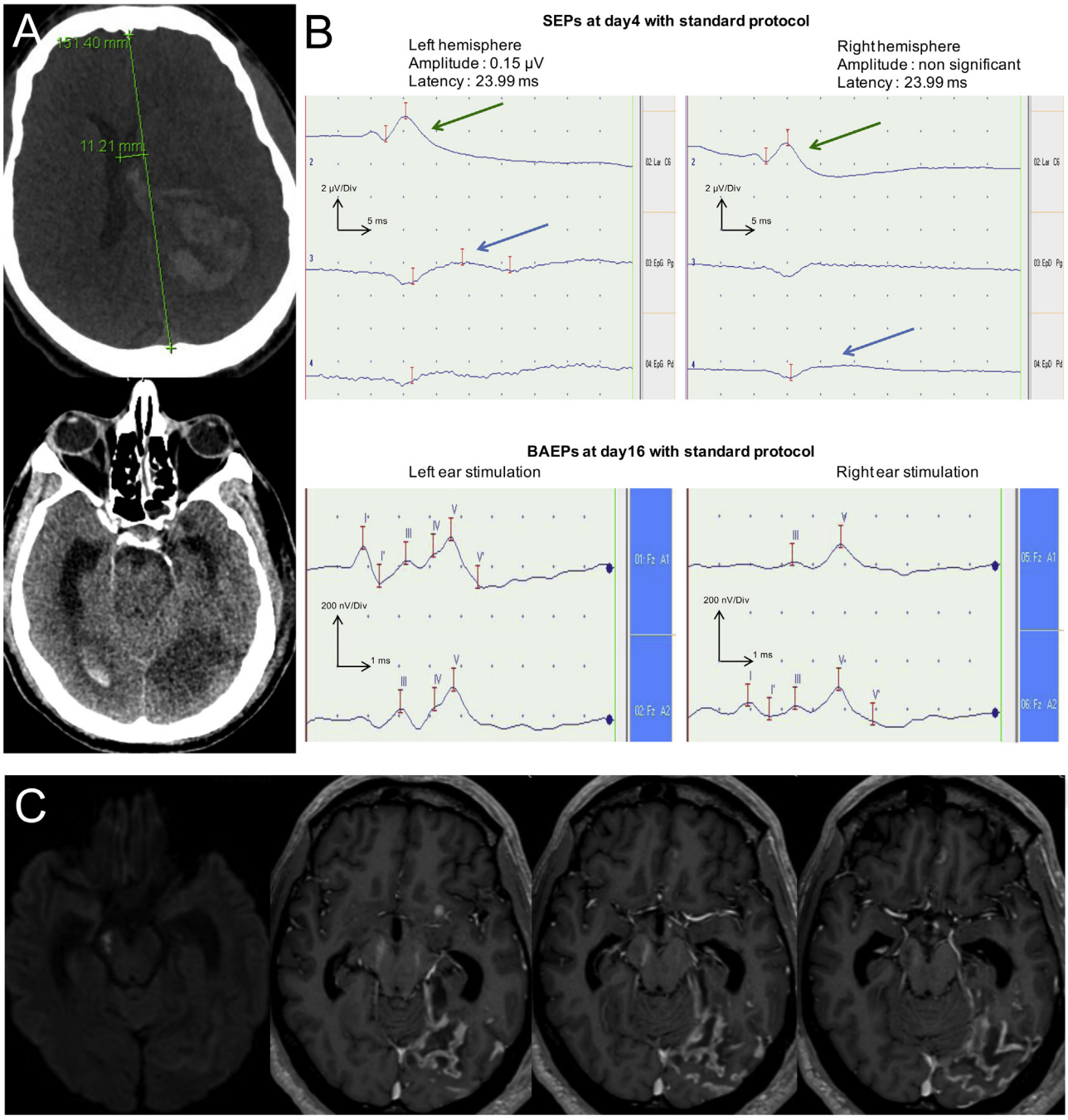


**Fig. 1.** Radiological and neurophysiological features of Patient 1. A: Upper part: Initial axial CT-scan at Day 1; Bottom part: Follow-up axial CT-scan at Day 4. B: Upper part: Static assessments of SEPs at Day 4 (green arrows for cervical-N13; blue arrows for asymmetric cortical-N20); Bottom part: Static assessments of BAEPs at Day 16 (orange arrows for inferior-mesencephalon Peak V). The second SEPs assessment confirming the right-hemispheric abolition at day 16 has not been presented. C: Axial MRI at Day 25 showing the lesion at the lateral and superior portion of the right mesencephalon (DWI sequence on the left); Right part: axial MRI image (T1 sequence after Gadolinium injection) indicating a blood-brain barrier alteration. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)