

Abstracts

Characterization of Vagus Nerve Electroneurogram in Kainic Acid-induced Temporal Lobe Epilepsy

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Rationale: Seizures produce autonomic symptoms, primarily sympathetic but also parasympathetic in origin. The vagus nerve (VN) is a key player as it transmits information between organs and the brain. Exploiting vagal neural traffic in relation to seizures may offer a novel approach to seizure detection and the development of closed-loop Vagus Nerve Stimulation. The kainic acid (KA) model of temporal lobe epilepsy (TLE) produces spontaneous recurrent focal seizures with secondary generalization. In a previous study, we characterized vagus nerve electroneurogram (VENG) in acute KA-induced seizures under anesthetized conditions and developed a VENG-based seizure detection algorithm. This project aims to characterize the VENG in spontaneously occurring temporal lobe seizures.

Methods: Status epilepticus (SE) was induced in 3 Wistar rats by intraperitoneal injections of KA (5 mg/kg) following the Hellier protocol. Clinical seizures were continuously monitored visually and scored according to the Racine scale. KA treatment was repeated hourly until the animals displayed stable, self-sustained SE for at least 3 hours.

After a minimum of 3 months after SE induction, all rats exhibited spontaneously occurring seizures. The left cervical VN was implanted with a cuff electrode for VENG recording. Epidural electrodes were implanted for scalp EEG monitoring with coordinates [GND]: AP:-2, ML:±3; [PL/PR]: AP:5, ML:±3; [REF]: AP:-6, ML:0. Surgical procedures were performed under sevoflurane anesthesia. VENG and video-EEG were recorded continuously for 24 hours.

Seizures were characterized by high-frequency rhythmic spiking activity, evolving into spike-and-wave discharges lasting at least 10 sec, and were categorized into two groups based on severity: Seizures were divided in two categories: non-convulsive seizures (stages 1–2) and convulsive seizures (stages 3–5). Ictal VENG segments were identified based on corresponding ictal EEG patterns, and only non-moving segments were analyzed to avoid bias of movement artifacts. The VENG Root Mean Square (RMS) was computed in non-moving extracted segments and compared to 10 sec pre-ictal segments and reported as a percentage of change.

Results: Group 1 (n=21) had an average duration of 48 ± 5 sec, while Group 2 (n=7) lasted 61 ± 26 sec. The VENG segments extracted for analysis averaged 15 ± 5 sec for Group 1 and only 2 ± 1 sec for Group 2, due to the severity of the seizures limiting analyzable segments after the beginning of the seizure. The mean RMS change was $156.3 \pm 71.6\%$ for Group 1 and $51.2 \pm 30.2\%$ for Group 2. The delay between the EEG onset and the appearance of VENG changes could not be calculated due to movement artifacts at the beginning of the seizures.

Conclusions: An increase in vagus nerve activity was observed during spontaneously occurring seizures in the KA model of TLE. It could be the base for seizure detection, with future use in closed-loop stimulation strategies.

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Translational Research