ABSTRACT

- Neuromodulation has been an alternative treatment in patients with drug-resistant epilepsy, especially when patients who are not candidates for surgical intervention.
- A system-on-chip (SoC) including a 16-ch signal acquisition unit, a bio-signal processor, a 16-ch adaptive stimulator, and wireless telemetry designed for human seizure control is under development.
- Utilizing swine to develop an acute epilepsy model, we validated the accuracy of seizure detection and efficiency of seizure control of the system.

RESULTS

- So far, 4 pigs were utilized.
- Focal periodic epileptiform discharges developed from injection site, and subsequently extended to remote site ipsilaterally within 20 to 30 minutes after subcortical injection of PCN. (Figure 3A)
- If the pigs were left without neuromuscular blockade, shock-like movement temporally locking to cortical polyspike-discharge appeared rhythmically.
- Runs of generalized epileptiform discharges for 60s seconds were reproduced by 2-Hz direct-cortical stimulation. (Figure 3B)
- The generalized epileptiform discharges would be suppressed once the closed-loop SoC system was switched on. (Figure 3C)

METHODS

Pigs
- domestic swine, weighting 35-50 kg were utilized

Anesthesia
- Induced with initial intramuscular injection of azaperone (40mg/mL, 5–6 mg/Kg) and atropine (1mg/mL, 0.03-0.05 mg/Kg).
- Lateral injection of Teletill (tiletamine and zolazepam, 3–5 mg/Kg).
- Maintenance anesthesia with isoflurane

Surgery
- After prone positioning, craniectomy, and dural opening, planar grid-electrodes implant (2.3 mm exposed diameter, inter electrode distance 1 cm center to center; Ad-Tech, Racine, USA) was assessed.

Epileptiform activity induction
- Subcortical injection of Benzyl-Penicillin (PCN) 5000U (5 mm below the cortical surface)
- Electric currents (4 to 10 mA, 2 Hz, 300 µs pulse width, 10 s) were applied to neighboring electrode pairs after PCN injection.

Features of closed-loop seizure control SoC design
- Low-noise neural-signal acquisition unit (2.07uVrms)
- Accurate entropy-and-spectrum-aided seizure detection (>97%)
- Configurable current stimulation (0.5-3mA)
- Wireless power and data telemetry in single pair of coils

CONCLUSIONS

- Neuromodulation has been an alternative treatment in patients with drug-resistant epilepsy, especially when patients who are not candidates for surgical intervention.
- Here we report the progress of the SoC including a 16-ch signal acquisition unit, a bio-signal processor, a 16-ch adaptive stimulator, and wireless telemetry designed for human seizure control.
- Utilizing swine to develop an acute epilepsy model, we validated the accuracy of seizure detection and efficiency of seizure control of the system.

ACKNOWLEDGMENT

This work was supported in part by Ministry of Science and Technology (MOST), R.O.C., under MOST105-2622-B-009-004 and in part by “Aim for the Top University Plan” under Biomedical Electronics Translation Research Center of National Chiao Tung University and Ministry of Education, Taiwan, R.O.C.