Functional comparison of analog and digital mouse telemetry implants in cardiac arrhythmia detection

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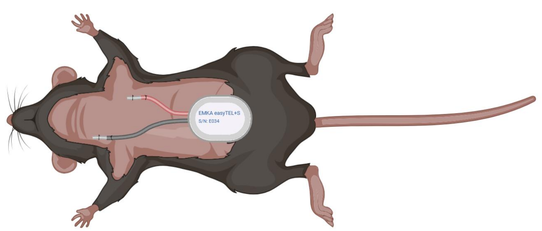
Abstract

Telemetry enables real-time, continuous monitoring of cardiac electrical activity in mice over extended time, which facilitates the interpretation of disease induction and its development. Analog and digital telemetry exist for preclinical research using small laboratory animals, and each technology is best suited for specific applications. Analog telemetry systems provide continuous, high-resolution data without compression, preserving subtle physiological details better than digital systems. In contrast, digital telemetry offers improved signal stability, reduced noise, and data storage efficiency. Here we evaluate the functional differences between analog and digital telemetry implants, in the context of cardiac electrophysiology studies.

Methods

SCIREQ/EMKA analog EasyTEL S-ETA and digital S_CTA implants were compared after being implanted in 20 adult male mice. The implants were located within the abdominal cavity, with electrodes sutured subcutaneously to the thoracic muscles in a Lead II configuration. The animals were given 7 days of post-surgical recovery. Analog S-ETA implants were paired with easyMATRIX3 units to digitize the body temperature, activity, and ECG signals, while digital S_CTA sent their signal directly to IOX2 data acquisition systems. The ecgAUTO software was used to extract the intervals from the recordings. Proarrhythmic drugs , hypoxic conditions, and animal handling were used to exacerbate the differentiators in performance for the technologies.

Analog and Digital Implants Require the Same Surgical Procedure

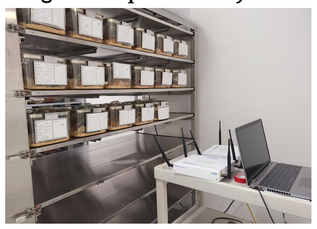


- Laparotomy and lead attachment;
- Analgesics for pain management;
- 7-10 days of recovery prior to any data acquisition.

Results

Analog Acquisition System

Digital Acquisition System

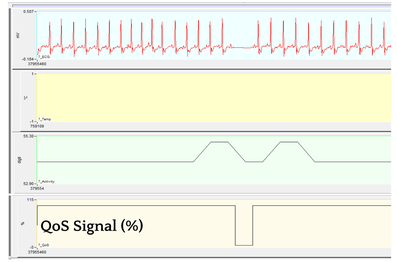


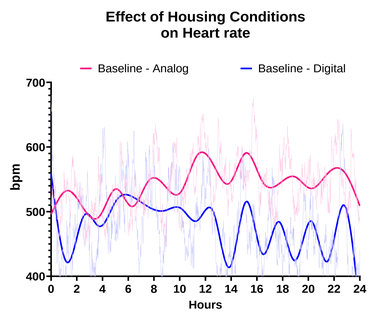
- The analog acquisition pads are assigned to one animal and have a limited range; each animal needs to be single-housed, and the animal's cage must lay on the acquisition pad, or at least be very close to it.
- Using the digital receiver means the mice can be group-housed and remain in ventilated racks. The steel racks generally interfere with analog signal acquisition.

Digital Telemetry Comes with the Addition of the "Quality of Signal" Channel

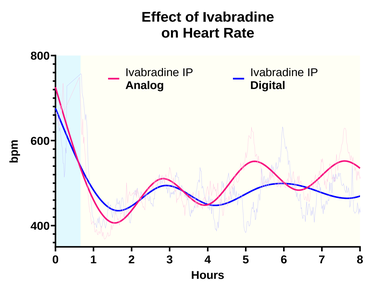
The "QoS" signal indicates when the digital implants are disconnected from the receiver.

This improves analysis efficiency.

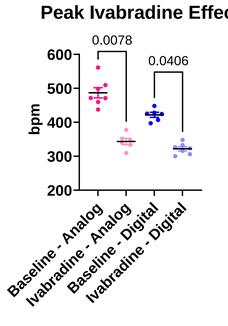


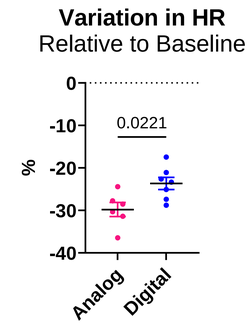


Animals implanted with analog probes – and single-housed – displayed basal heart rate values **10%** higher than those of animals implanted with digital implants – and pair-housed.

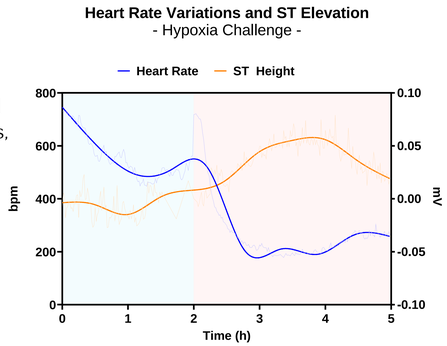


Both Systems Capture the Bradycardic Effect of Ivabradine (10 mg/Kg, I.P.). All animals reached similar HR values at Ivabradine's peak effect.





Measured Drug Effects May be Overestimated in Single-Housed Animals



The digital system could be used in hypoxic racks, monitoring the animal's bradycardia and ST segment elevation.

The analog system is unsuitable for this challenge.

Conclusions

Benefits of the Digital System

- Ideal in studies where co-housing or group housing is needed/required.
- Well-suited for studies involving variable environments (Such as behavioral studies – e.g. combination with maze, pool, treadmill)
- Manage implants sleep/on mode remotely – animals are not disturbed through human interaction
- Longer transmission range for more versatile use (3-5 m)
- Single & Dual biopotential, pressure, temperature, activity
- QoS facilitates qualitative analysis & arrhythmia detection
- Traceability/diagnostics capability facilitates IACUC approval

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