

Mouse Electrocardiogram

Equipment: **Power Lab/4SP with ML135 Dual Bio Amp and MLA0112 ECG Lead Switch Box**
(AD Instruments)
5 needle electrodes (AD Instruments)
iBook (Mac) computer
Temperature/Heart Rate Monitoring System for mice as with Doppler testing

Supplies:

- Isoflurane inhalation anesthetic
- Heat lamp
- Masking tape
- Gauze

General Information:

The electrocardiogram (ECG) is recorded and analyzed using a digital acquisition and analysis system (Power Lab/4SP; www.adinstruments.com) We connect a “Dual Bio Amplifier” to an “ECG Lead Switch Box” to enable recording of standard lead configurations from 5 lead wires (i.e. type I, II, III, aVF, aVL, aVR configurations). Chest electrode configurations V1-V6 may be obtained by moving one electrode to different chest positions. For routine screening, we record the surface ECG (lead II) from needle electrodes that are inserted subcutaneously in the limbs and secured with tape. If the lead II ECG is abnormal, other lead positions may be used to validate and/or further characterize the ECG abnormality. The surface ECG tracings are filtered using a high pass setting of 0.3 Hz and low pass setting of 1 kHz. The recorded ECG is analyzed using the SAECG (signal-averaged electrocardiogram) extension for Chart 4 (v 4.2.3 for Macintosh, AD Instruments).

Procedure:

The mouse is anesthetized with 1-2% isoflurane in 700 ml O₂/minute via facemask (following induction in a chamber containing 5% isoflurane). Rectal temperature is continuously monitored and maintained within 37-38°C using a heat pad and heat lamp. The lead II ECG is recorded from needle electrodes inserted subcutaneously into the right forelimb and into each hindlimb. The signal is acquired for about 1 minute using Chart 4.2.3 software on the iBook. The recorded signals must be free of noise and electrical interference. When recording is finished, the anesthetic is turned off, and the rectal temperature probe and limb electrodes are removed. The mouse is allowed time to wake up while breathing 100% oxygen and is then returned to its cage. Each test takes ~ 5 min including anesthetic induction and recovery time.

During offline analysis, we examine the 1 minute recording for unusually shaped P, QRS, or “T” waves (see note below) and for time-varying phenomenon (e.g. irregularities in interval durations). Ectopic or abnormal beats are noted. A representative 10-15 s segment of the recording is averaged to obtain the signal averaged ECG). The SAECG waveform and the 1st derivative are displayed and markers applied as described below and as shown in the diagram. The following parameters are then automatically calculated from the marked SAECG waveform:

Heart Rate (bpm)	The reciprocal of the average RR interval between valid beats.
P duration (ms)	Time interval between P wave markers (P1 to P2).
PR duration (ms)	Time interval between the first P wave marker and the first QRS marker (P1 to Q1).
QRS duration (ms)	Time interval between the QRS wave markers (Q1 to Q2).
QTmax duration (ms)	Time interval between the first QRS marker and the time of the maximal amplitude (positive or negative) of the “T” wave (Q1 to Tmax).
QT duration (ms)	Interval between the first QRS marker and the second “T” wave marker (Q1 to T2).
QTc duration (ms)	The QT interval ‘corrected’ for heart rate according to the formula

$$QTc = QT / (RR/100)^{0.5}$$

(Correction equation from: *Mitchell GF, et al. Measurement of heart rate and Q-T interval in the conscious mouse. Am J Physiol. 1998 Mar;274(3 Pt 2):H747-51.*)

QRS height (mV)	The maximum value occurring between the QRS markers, minus the minimum value.
P height (mV)	The maximum value occurring between the P wave markers, minus the minimum value.
“T” height (mV)	The maximum value occurring between the “T” wave markers, minus the minimum value.
Number of cycles	The number of cardiac cycles included in the averaged ECG waveform.

Reported Results:

For each mouse a summary report of the above variables is generated.

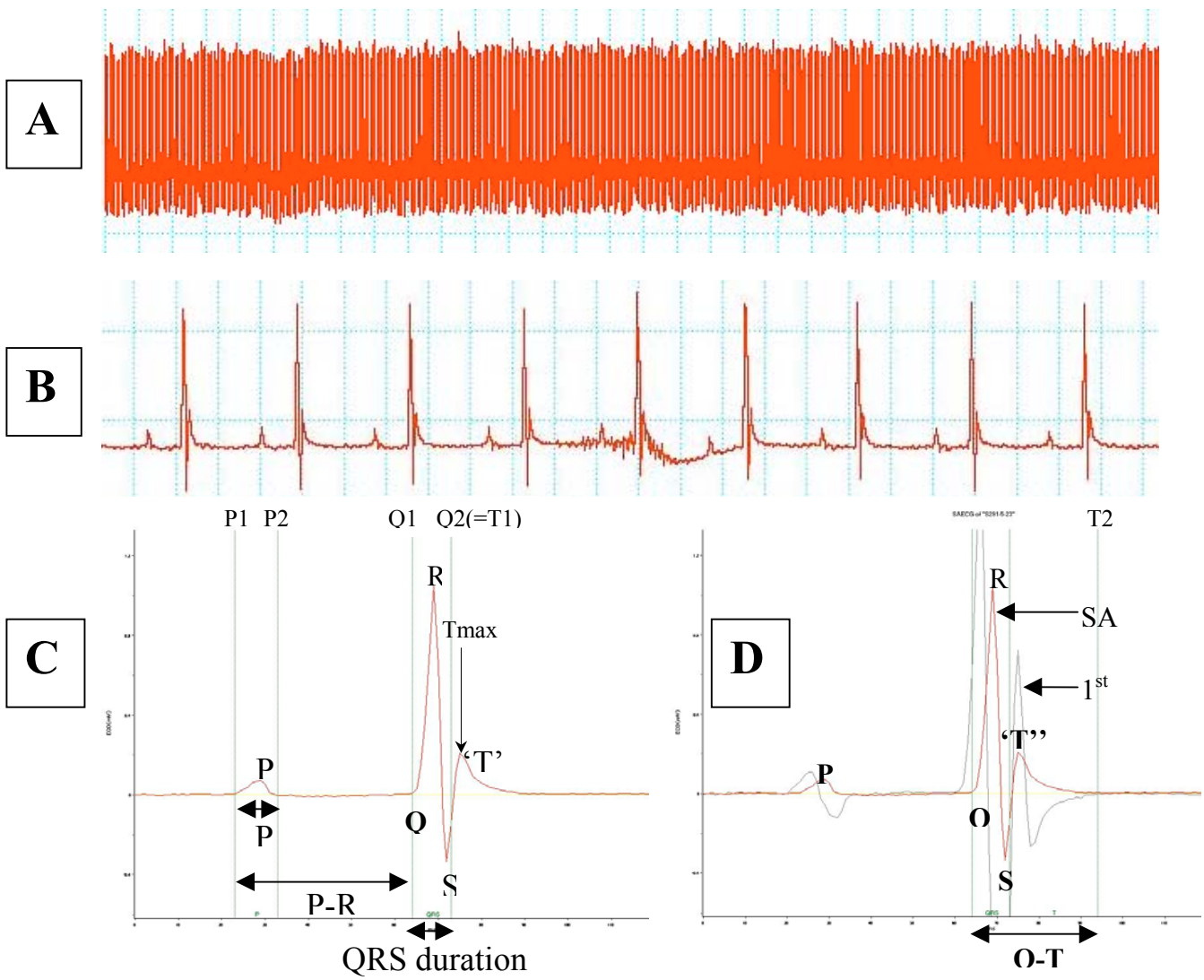
Note regarding the mouse “T” wave:

Whereas the P wave and QRS complex of the mouse ECG is very similar to the human, the ventricular repolarization phase of the ECG (the T wave in humans) is different in mice. The software we use was designed for the human ECG so we call the wave that immediately follows the QRS complex the “T” wave in accord with the software. However, the “T” wave corresponds to early ventricular repolarization in the mouse and should arguably be referred to as a J wave instead. For further information on this phase of the mouse ECG see “*Liu G, et al. In vivo temporal and spatial distribution of depolarization and repolarization and the illusive murine T wave. J Physiol. 2004;555(Pt 1):267-79.*”

Acknowledgements:

The CMHD requests that the users of our screening service acknowledge the technical assistance of our facility in any presentations or publications that report results generated by our services. A suitable acknowledgement for publications is as follows: “The authors would like to acknowledge the Samuel Lunenfeld Research Institute’s CMHD Mouse Physiology Facility for their technical screening services (www.cmhd.ca).”

Additionally, please send reprints or information on such publications or presentations when they are submitted or available. Such acknowledgements will help promote the use of our service and assist us in obtaining continued financial support to help defray service fees.



- One minute lead II ECG recording.
- Scroll through recording to look for time varying abnormalities.
- Calculate signal-averaged ECG over 10-15 s of recording. Measure P wave duration (P1 to P2), P-R interval (P1 to Q1), and QRS duration (Q1 to Q2) by aligning vertical blue cursors as shown. Q2 is marked at the point of inflection between S and T_{max}, or at S if there is no point of inflection.
- Superimpose the 1st derivative of ECG. Q-T interval ends when 1st derivative is zero (T₂). Intervals are transferred automatically to the database and compared to reference data to identify outliers.