ECG Lead Placement in Large Quadrupeds

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Good quality ECG recordings require proper lead placement technique. A technique developed and used at our lab meets the requirements for ease of placement and provides excellent recordings. The use of implantable radiotelemetry provides an excellent means of collecting very high quality, low noise ECG signals for extremely long durations in the ambulatory animal. In many respects the technology is revolutionary and offers researchers new and exciting possibilities. However, the technology is new to many in the research community, and the basic ground rules are slightly different than those which we are familiar with from our previous experiences with more conventional ECG recording methodologies.

The use of telemetry implies that the test subjects will be active. Thus, elimination of interfering electrical signals is important. High quality, low noise ECG signals can be easily collected if relatively large surface area electrodes are located close to the heart -- along the electrical axis of the heart and away from large muscle masses that create interfering electrical potentials.

A major advantage of implantable ECG electrodes is that they are located in a highly conductive environment and avoid the very high impedance of the skin. Reducing impedance minimizes a major cause of low amplitude ECG signals. Further, subcutaneous electrode placement avoids dermal irritation problems that severely limit continuous use of standard skin electrodes.

DSI telemetry systems provide bipolar electrodes that are well suited to ECG data collection. More than one pair of ECG leads may be requested; however, the most common use is as a single pair of leads configured in combination with another type of sensor, typically blood pressure.

The bipolar configuration of the telemetry system is the standard limb lead system commonly used for leads I, II, and III. Consequently, a lead placement that emulates one of these standard leads is suggested. Generally speaking, lead II is ideal for most animal species.

For most animals, the frequently used lead II configuration provides large amplitude deflections that are easily recognized both visually and by automated data reduction systems. Rate, rhythm, and morphology can be easily ascertained from the single lead configuration. Further, arrhythmia analysis can be readily performed. Since high quality data are available for extended periods of time, the usefulness of the technique is limited only by one's creativity and the transmitter battery life.

To emulate lead II, we utilize subcutaneously placed electrodes located in line with the long axis of the heart. One electrode is placed in the upper right quadrant of the chest and the other in the lower left quadrant of the chest in the dog. To minimize muscle artifact, the electrodes are placed beneath the overlying musculature. The electrodes are placed as deep as possible without penetrating the underlying body cavity. This approach puts the electrode close to the heart without violating the pleural or peritoneal space. Not only is the surgery simplified, but amplitude of the desired cardiac electrical signal is enhanced.

The upper right electrode can be placed just below the pectoral muscles against the rib cage near the first interspace. In the dog, the lower left electrode can be placed in an interspace on the left caudal-lateral thorax beneath the abdominal muscles. In the rat, the lower left electrode is placed within the muscle tissue in the lower left abdominal wall, just cranial to the groin area. Several variations of these locations can be used to meet specific experimental requirements, but keeping the electrodes located along the electrical axis of the heart will provide the largest amplitude signal.

To facilitate placement of the electrode wires, a tunneling device (a trochar) is a useful accessory. These devices are commercially available, however an adequate tunneling device can be fashioned from a length of thin walled stainless steel tubing, large enough for the insulated electrode wire to be easily inserted through. The tunneling device must be passed from the site of the electrode insertion to the site of transmitter installation. In some cases, it is necessary to tunnel in two steps. For example, if a transmitter is located subcutaneously on the flank of a dog, both electrodes can be first tunneled to the lower left location and then one electrode tunneled to the upper right location. Tunnel the wires before preparing the leads for implantation in the muscle.

Adequate electrode surface area of the sensing electrode is vital to obtaining a large amplitude signal. Consequently, we recommend increasing the surface area of the electrodes by removing insulation from 10 to 15 cm of the electrode wire for dogs and removing about 7 to 8 cm of insulation for primates. When long, the wire is best managed by coiling it into a series of loops. This can be easily accomplished by placing a non-dissolvable suture in a small hemostat, wrapping the bare wire around the tip of the hemostat and then tying the bare loop of wire together with the suture. This technique keeps the loop under control during placement. The loop should then be securely sutured into place to prevent migration.

The polarity of the electrodes is marked. By convention, the negative electrode (clear silastic lead) should be placed near the base of the heart (upper right) and the positive electrode (red silastic lead) should be placed near the apex of the heart (lower left). If after implantation it is determined that the leads have been reversed, an inverted polarity can be easily corrected in the software configuration of the Dataquest® system for the particular transmitter by placing a negative sign in front of the channel's calibration value.

The techniques outlined above were devised by Dr. Ron Moutvic at Battelle-Columbus. These approaches have been successfully employed for over nine years.

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