Location Matters – Data Logger Implantation in Nonhuman Primates

*Kasi Russell-Lodrigue[1] and Ásgeir Bjarnason[2]

SUMMARY

MOTIVATION

Implantable devices used to obtain temperature, electrocardiogram (ECG), heart rate, and activity data can be useful tools in laboratory animal research in support of the 3Rs through reduction of animal stress for regular collection of physiologic measurements without human interaction.

QUESTION

What are the optimal implantation locations for Star:Oddi DST milli-HRT and milli-HRT-ACT data loggers to record temperature, heart rate, ECG, and activity in macaques?

APPROACH

Star:Oddi DST milli-HRT and milli-HRT-ACT data loggers were surgically implanted subcutaneously (SQ) on the dorsum and intramuscularly (IM) between external and internal abdominal obliques in macaques to determine the optimal location for use in infectious disease studies.

RESULT

SQ implants were found to record higher quality ECGs and heart rates but lower overall temperatures with greater diurnal variation compared to IM devices. The IM approach required greater surgical expertise, was more invasive with longer post-operative recovery, and had higher costs compared to SQ implantation.

CONCLUSION

Pros and cons were identified for each potential implantation site, so study-specific needs must be considered prior to selecting the optimum data logger location.

1 Remote Physiologic Data Collection

Implantable devices capable of measuring and recording physiologic parameters such as temperature, heart rate, electrocardiogram (ECG), and activity can be useful tools in laboratory animal research in support of the 3Rs through reduction of animal stress for regular collection of physiologic measurements without human interaction. Data loggers were explored as alternatives to our traditionally used telemetry systems as a further refinement. Benefits of data loggers compared to our telemetry systems include:

- decreased surgery duration and invasiveness leading to shorter recovery times
- extended battery capabilities, precluding the need for multiple implantations with longer studies
- less associated equipment and personnel effort

2 Methods

Two data loggers were surgically implanted in each macaque, one subcutaneously on the dorsum and one intramuscularly between the external and internal abdominal oblique muscles, to allow direct comparison of physiologic values collected at each location. Star:Oddi DST milli-HRT (temperature, heart rate, ECG) and milli-HRT-ACT (plus activity) implants (Fig 1) were evaluated.

Subcutaneous (SQ) implantation:

- With the animal in ventral recumbency, a ~6-8cm skin incision is made on the dorsum between the shoulder blades.
- Using blunt dissection, a pocket is formed in the subcutaneous space that is large enough to accommodate the data logger.

Intramuscular (IM) implantation:

- With the animal in lateral recumbency, a ~6-8cm skin incision is made on the flank.
- Using blunt dissection, a pocket is formed under the external abdominal oblique muscle that is large enough to accommodate the data logger.
- The muscle is closed with absorbable suture.

Common procedures:

- The data logger may be secured within the pocket using suture.
- The pocket may be flushed with saline +/- antibiotics prior to closure.
- The skin incision is closed with absorbable suture in subcutaneous and subcuticular layers.

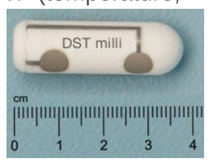

Figure 1. Star:Oddi DST milli data logger

3 Surgical Results

Compared to the SQ implantation procedure, the IM approach

- required greater surgical expertise to successfully create the pocket in the correct location without abdominal penetration
- was a longer, more invasive surgery with longer post-operative recovery
- had higher costs associated with the procedure (anesthesia, personnel)

On radiographs, dorsal SQ implants (Fig 2) may obscure portions of the right or left lung field on ventral-dorsal views, potentially limiting the assessment of pneumonic changes in infectious disease studies. IM implants may obscure abdominal organs on lateral views [not shown].

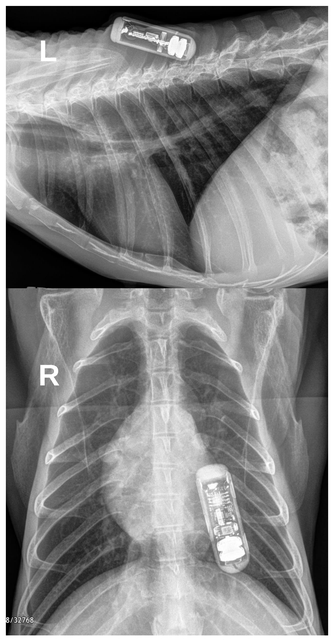

Figure 2. Top – left lateral radiograph showing implant in dorsal subcutaneous space
Bottom – ventral-dorsal radiograph with implant obscuring a portion of the left lung field

4 Temperature Results

IM implants recorded higher overall temperatures with less diurnal temperature variation compared to SQ devices (Fig 3 - top). The average difference in the range in daily temperatures was 2.4°C in SQ implants and 1.9°C in IM implants.

5 Activity Results

Similar result in activity levels were recorded through SQ or IM implants using calculated activity values provided by the implants (Fig 3 – bottom). IM implants showed promise of recording respiration during rest through the raw accelerometry data (Fig 4).

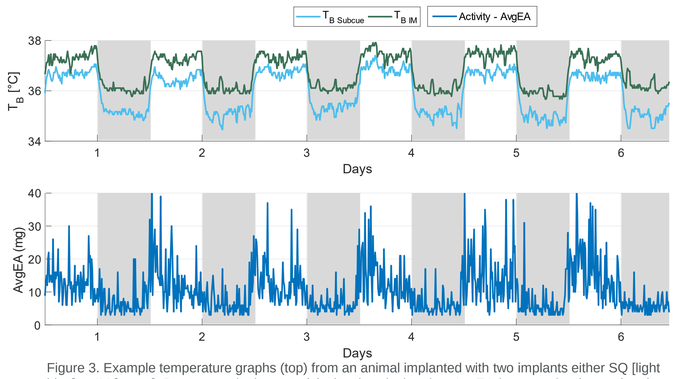

Figure 3. Example temperature graphs (top) from an animal implanted with two implants either SQ [light blue] or IM [green]. Bottom graph shows activity levels calculated as AvgEA (average 3 axis acceleration over 1 minute).

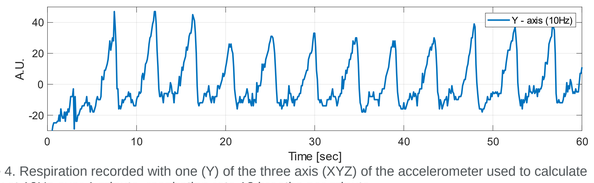

Figure 4. Respiration recorded with one (Y) of the three axis (XYZ) of the accelerometer used to calculate activity at 10Hz over 1 minute, respiration rate 13 breaths per minute.

6 Heart Rate / ECG Results

Heart rate recordings were processed based on quality index (QI) and threshold. QI=0 is the highest quality and QI=3 is the lowest quality ECG recording (Fig 5 – left). Subcutaneous implants were found to record higher quality ECGs and heart rate measurements due to artifacts caused by respiration in the IM implants (Fig 5 - right).

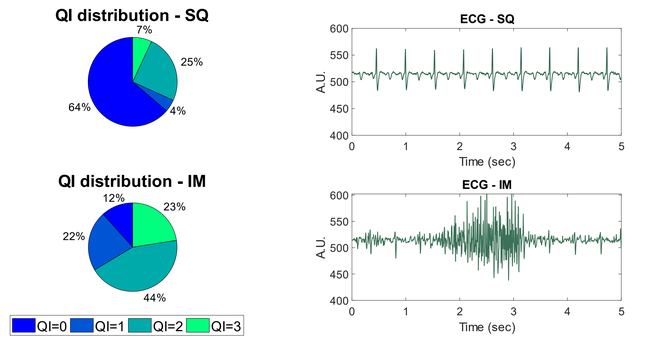

Figure 5. Quality index distribution for SQ implant (top left) and IM implant (bottom left) and example ECG Traces (top-bottom right) at rest for the two implant methods. Notice a lower amplitude for IM implant and EMG noise caused by respiration resulting in higher levels of QI.

7 Conclusions

Pros and cons were identified for each potential implantation site, so study-specific needs must be considered prior to selecting the optimum data logger location. IM implants provide more consistent temperature data for studies focused on febrile response to disease, and SQ implants are more appropriate for cardiac studies interested in acquiring ECGs. Both subcutaneous and intramuscular data logger implantation sites have now been used with success in different nonhuman primate infectious disease studies.

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[1]Tulane National Primate Research Center; Covington, LA
[2]Star-Oddi Ltd; Gardabaer, Iceland